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49 Recorders for air and gas.

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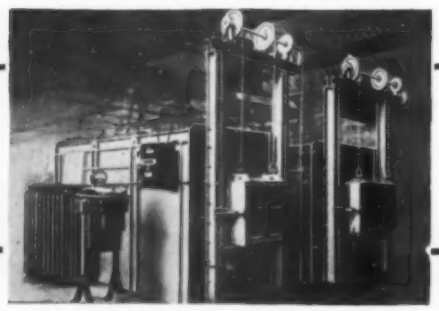
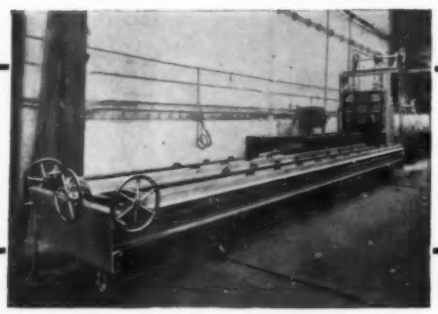


Furnaces for annealing, normalising, bright annealing, carburising, tempering, reheating, malleableising, oil tempering, cyanide hardening, nitriding, and high speed steel tool hardening. The illustration shows typical Metalectric box-type furnaces for general heat treatment purposes.

LIGHT ALLOYS



Furnaces for melting; billet heating; treatment of sheets, sections and components; forging. Salt Bath treatment. The illustration is of an electrically heated horizontal cylindrical furnace designed for annealing aluminium alloy sections at 400° C.

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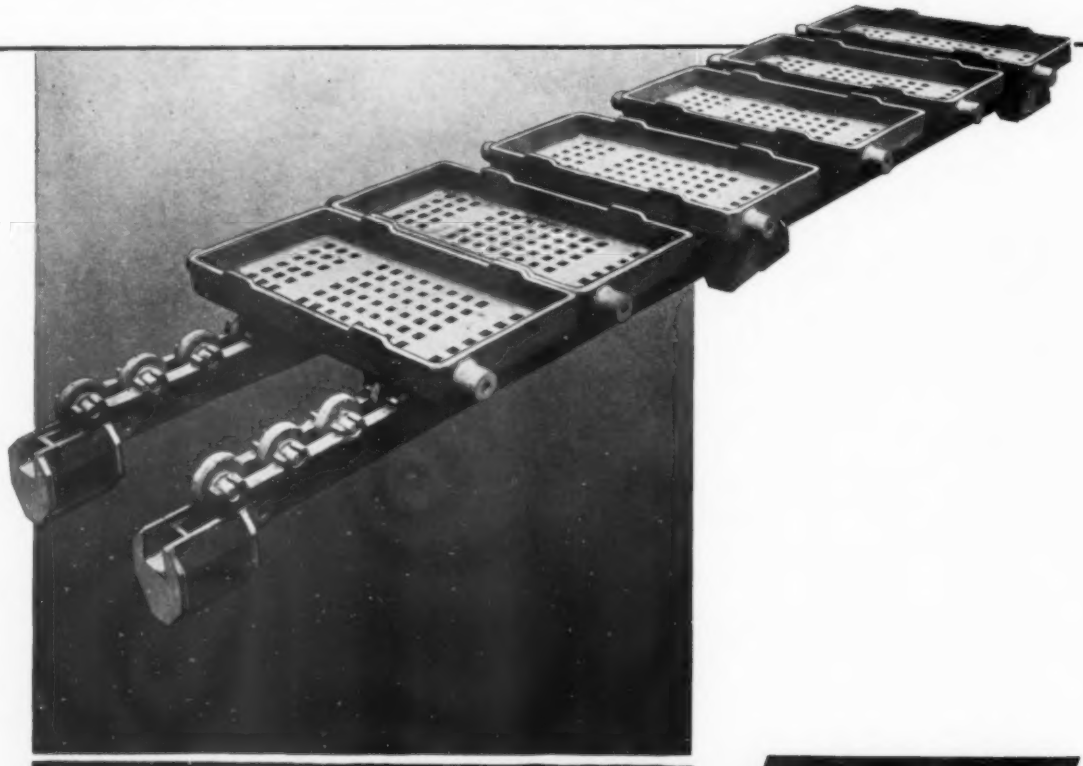

This section of a conveyor belt and trays for a continuous hardening furnace are made throughout of "Pireks" castings, a typical application of "Pireks" to the solution of a high temperature problem.

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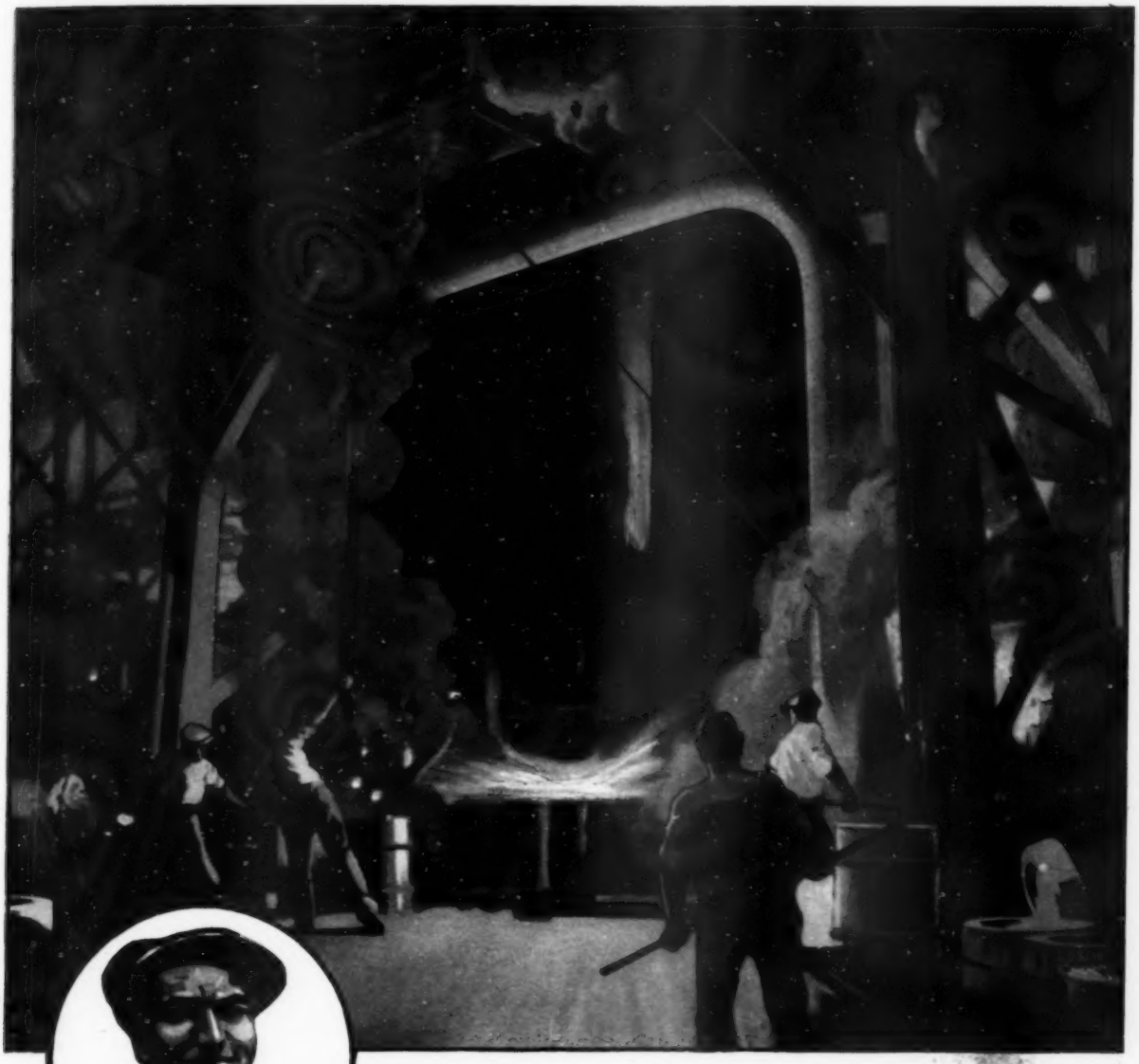

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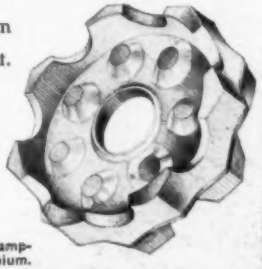

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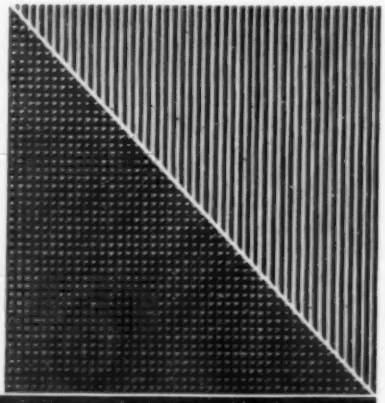

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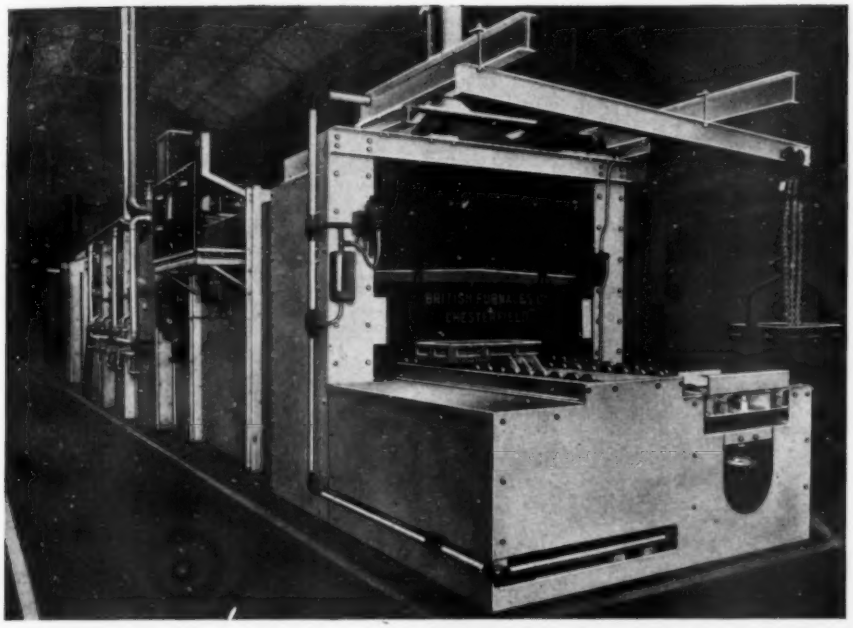


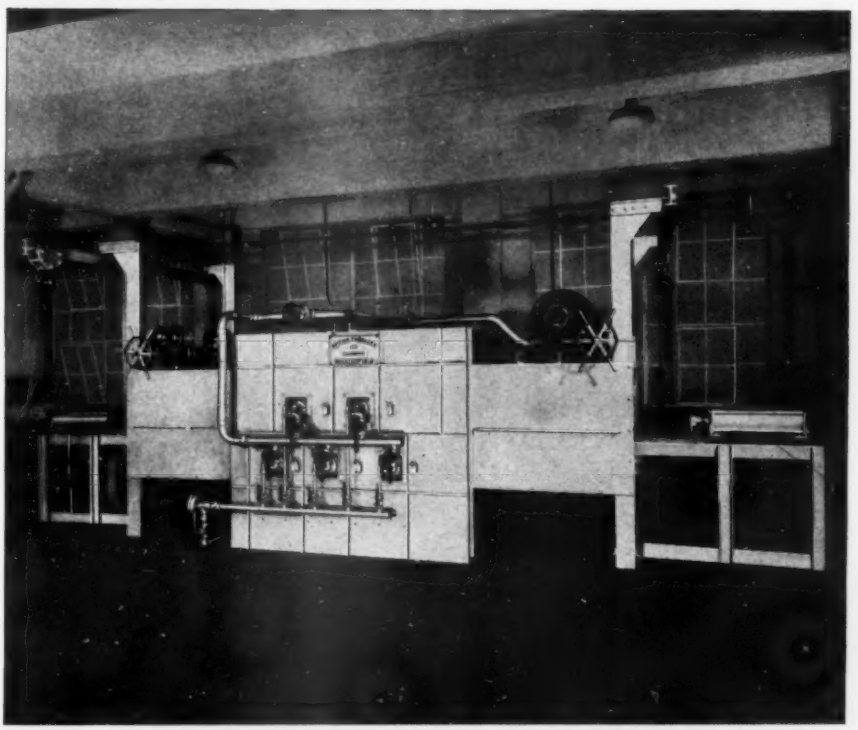
TWO RECENT INSTALLATIONS OF CONTINUOUS GAS-FIRED COUNTER-FLOW FURNACES FOR ANNEALING STEEL FORGINGS FOR THE AUTOMOBILE INDUSTRY WHERE QUALITY COUNTS

ABOVE :

FURNACE FOR AN OUTPUT OF 1500 LBS. STEEL FORGINGS PER HOUR HEATED TO 930°C. USING TOWN'S GAS IN AUTOMATIC PROPORTIONING BURNER EQUIPMENT.

RIGHT :

SIMILAR FURNACE ANNEALING 500 LBS. OF STEEL FORGINGS PER HOUR ALSO USING TOWN'S GAS IN AUTOMATIC PROPORTIONING BURNER EQUIPMENT.



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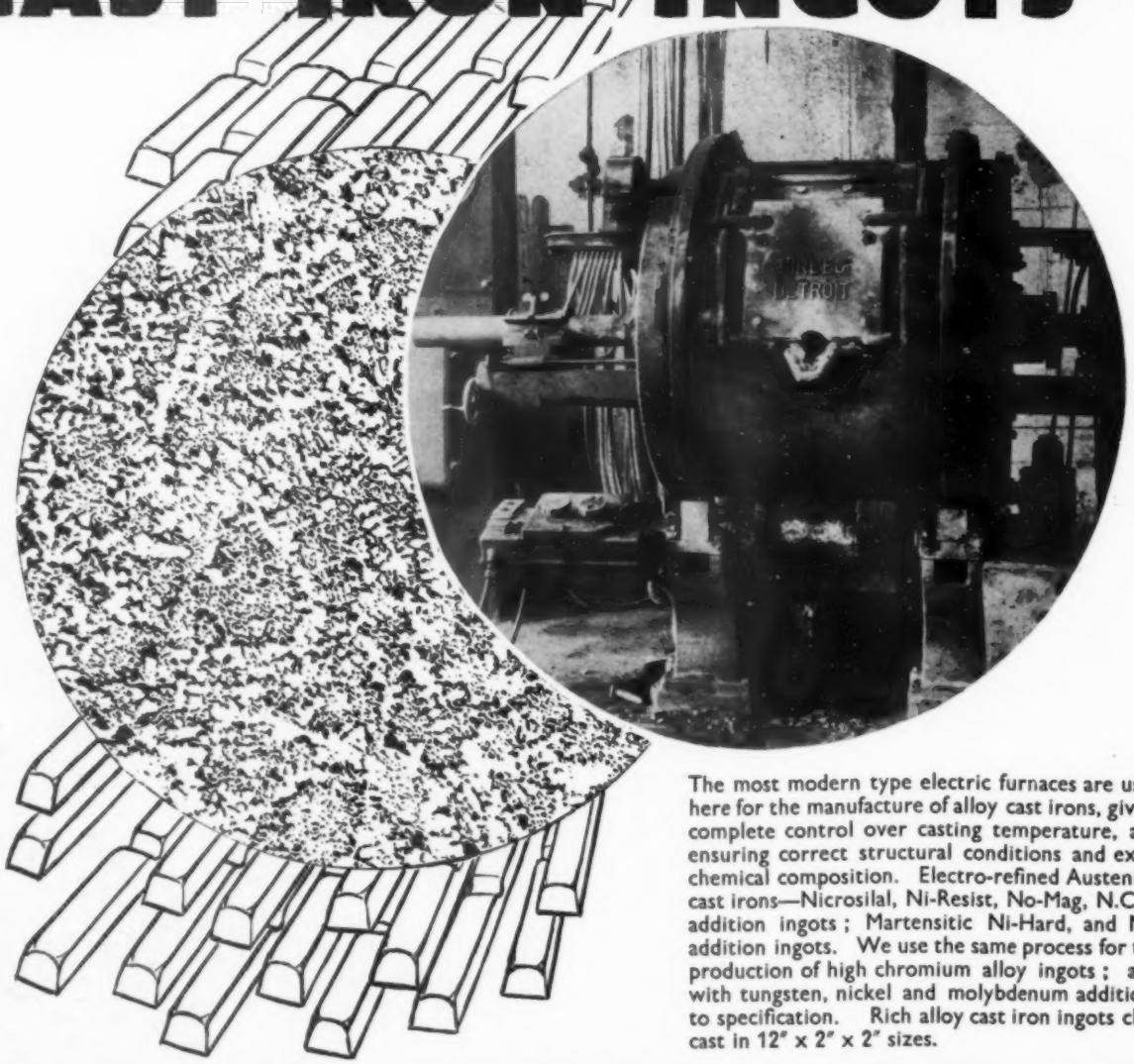

The most modern type electric furnaces are used here for the manufacture of alloy cast irons, giving complete control over casting temperature, and ensuring correct structural conditions and exact chemical composition. Electro-refined Austenitic cast irons—Nicrosilal, Ni-Resist, No-Mag, N.C.C. addition ingots ; Martensitic Ni-Hard, and NH addition ingots. We use the same process for the production of high chromium alloy ingots ; also with tungsten, nickel and molybdenum additions to specification. Rich alloy cast iron ingots chill cast in 12" x 2" x 2" sizes.

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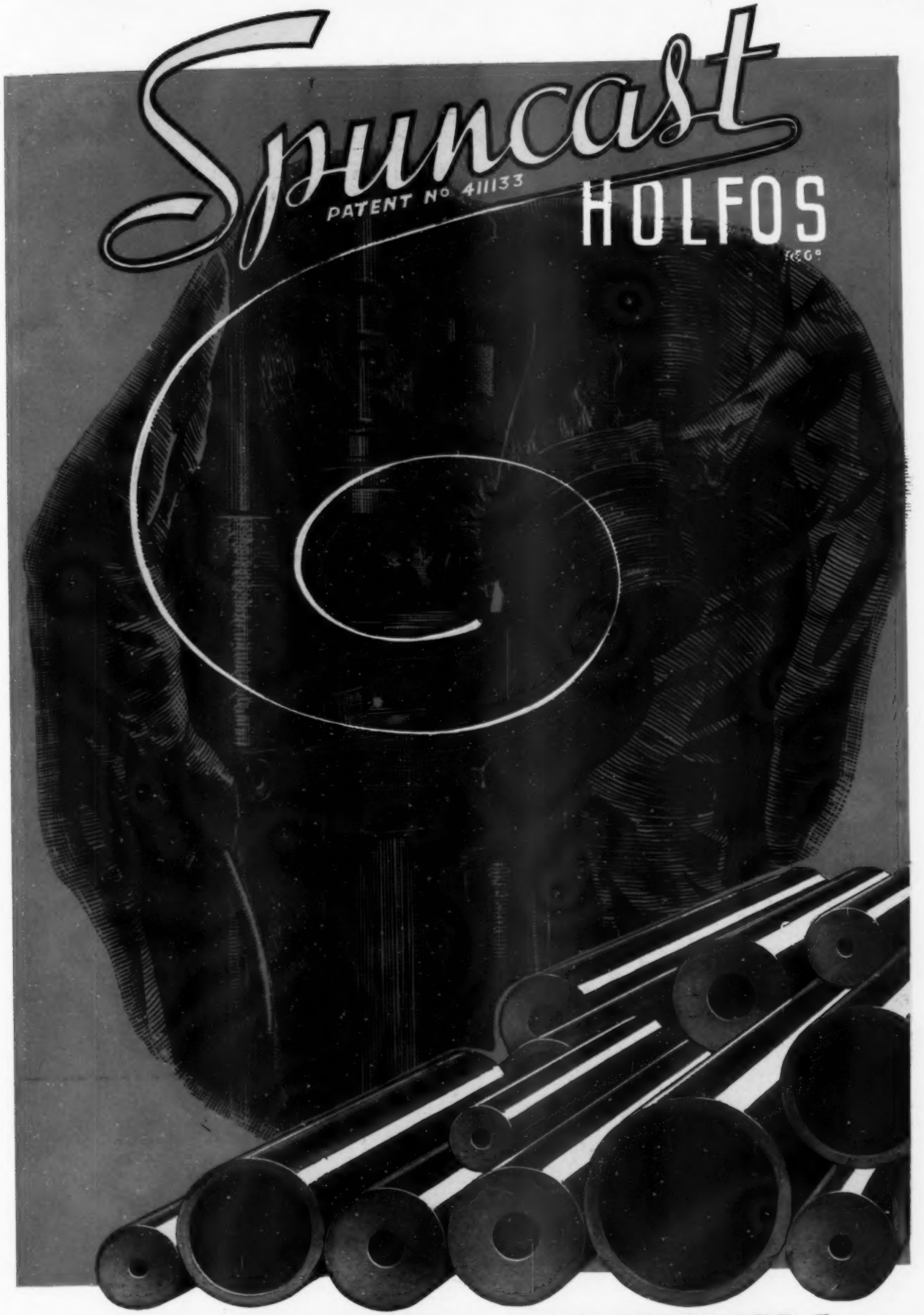

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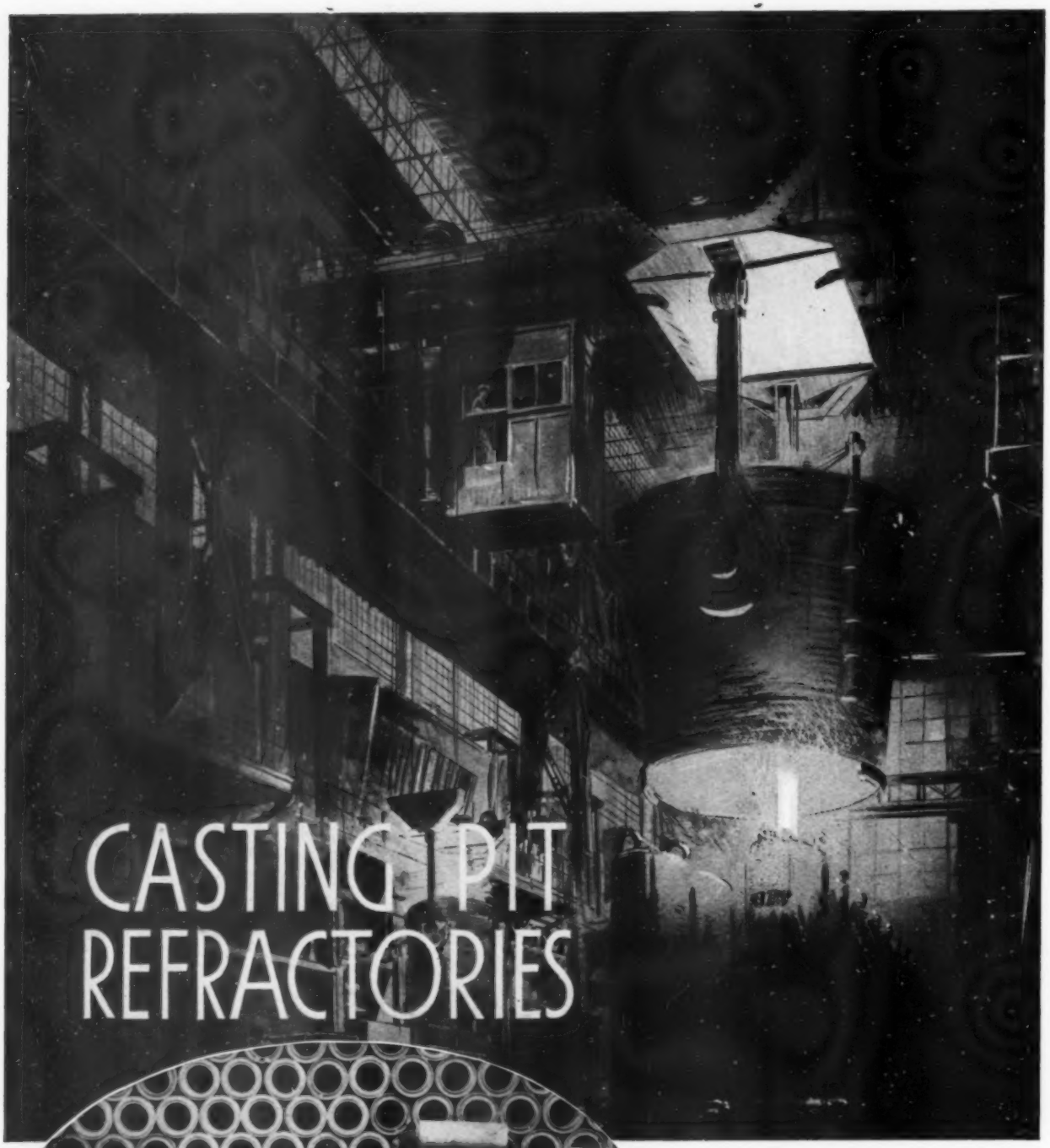

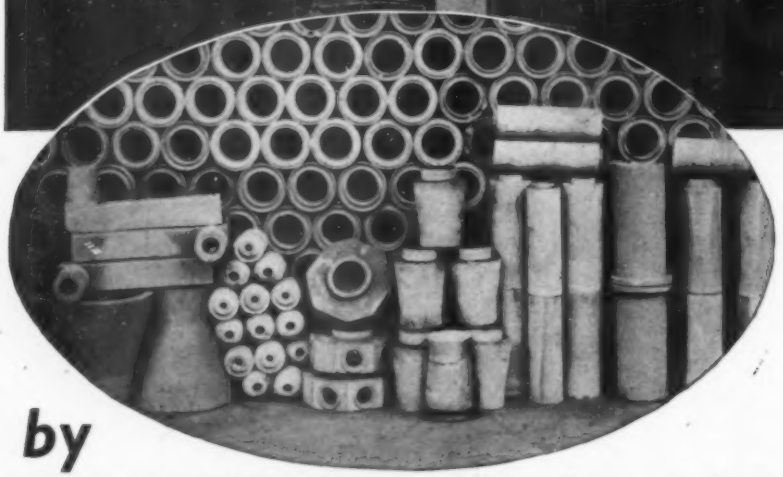

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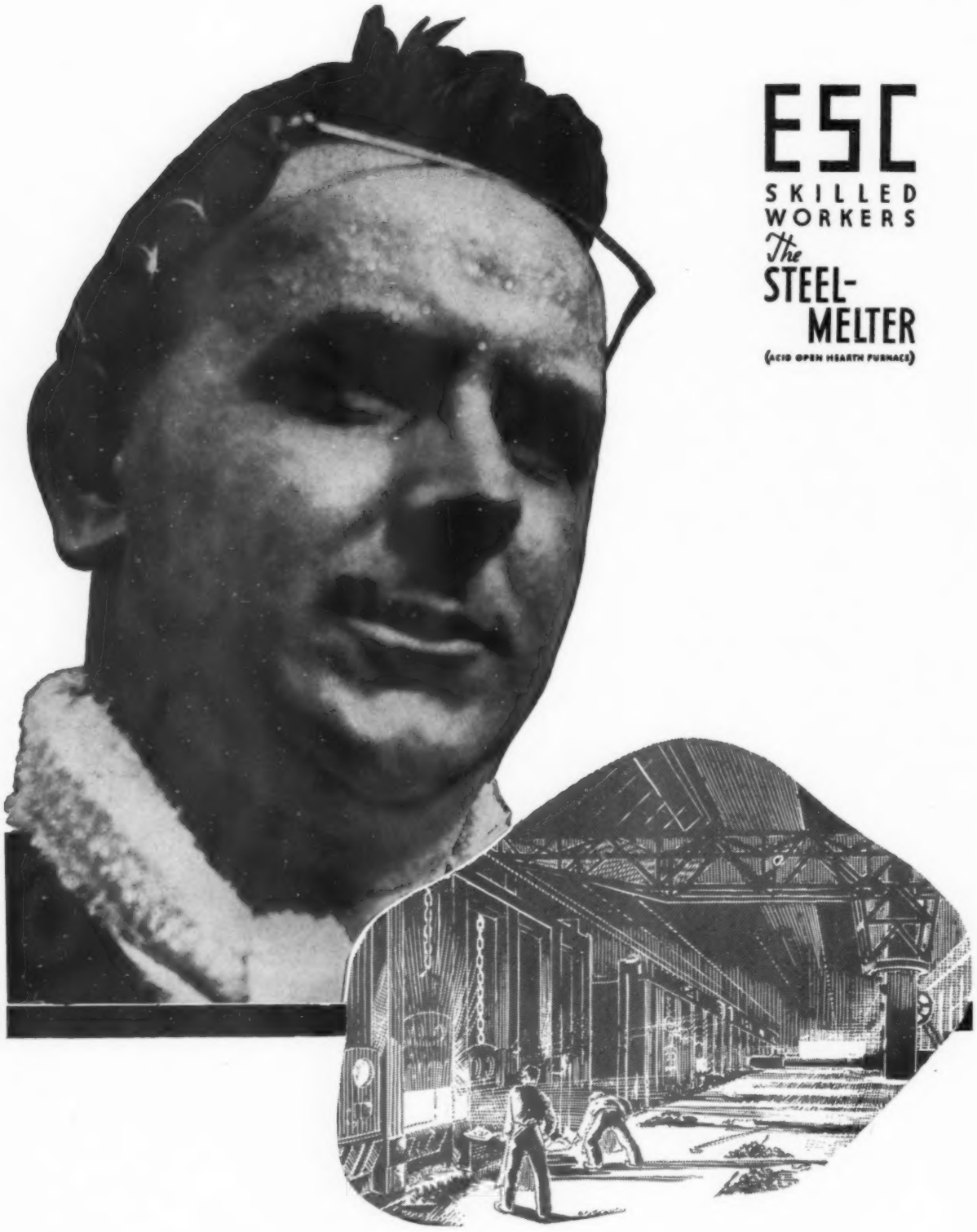

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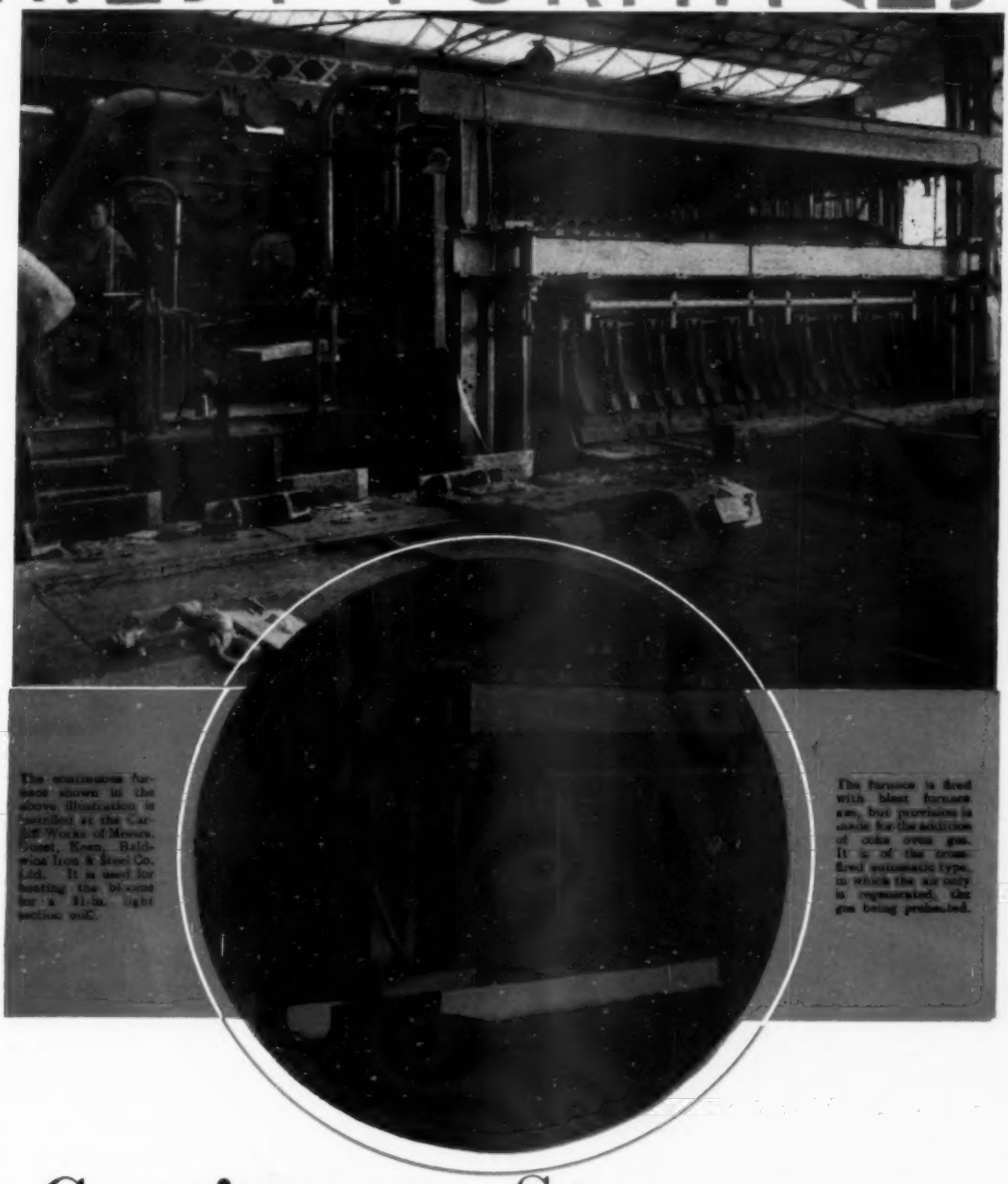

The continuous furnace shown in the above illustration is installed at the Cardiff Works of Messrs. Guest, Keen, Baldwins Iron & Steel Co. Ltd. It is used for heating the blooms for a 21-in. light section mill.

The furnace is fired with blast furnace gas, but provision is made for the addition of coke oven gas. It is of the cross-fired automatic type, in which the air only is regenerated, the gas being preheated.

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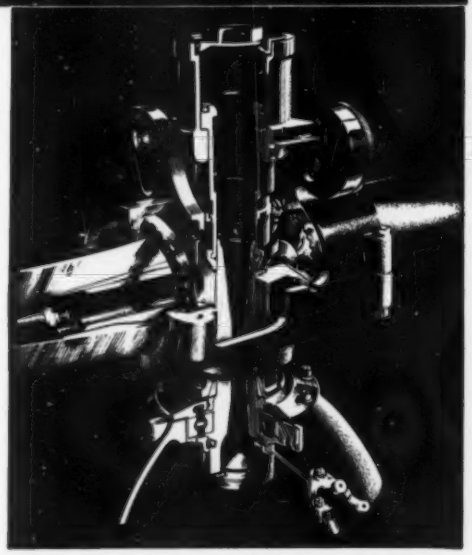

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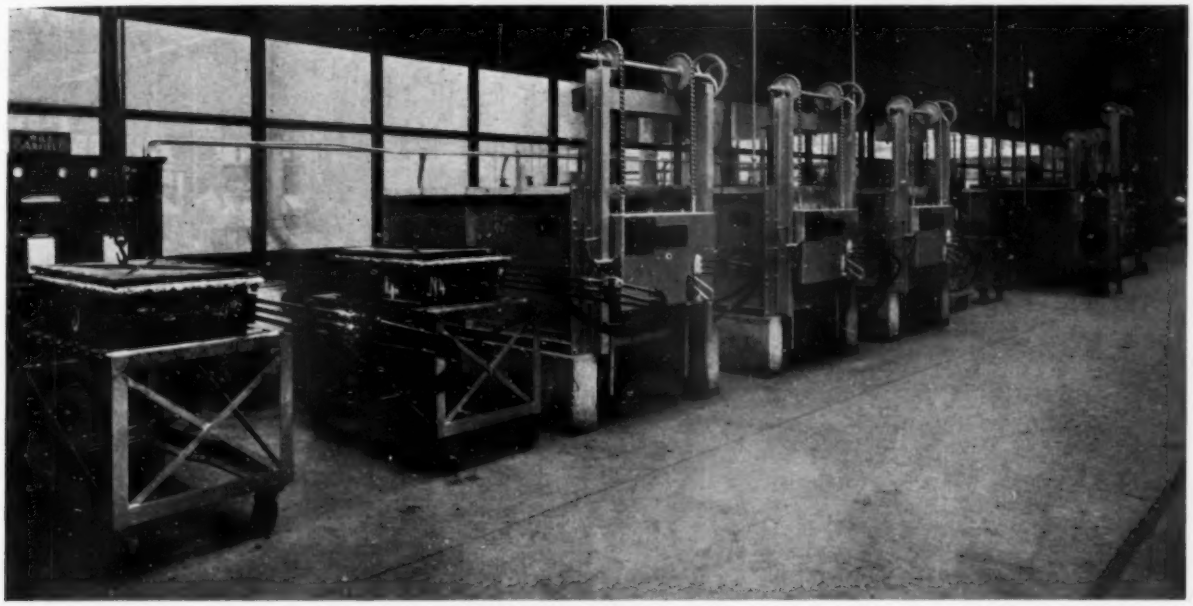

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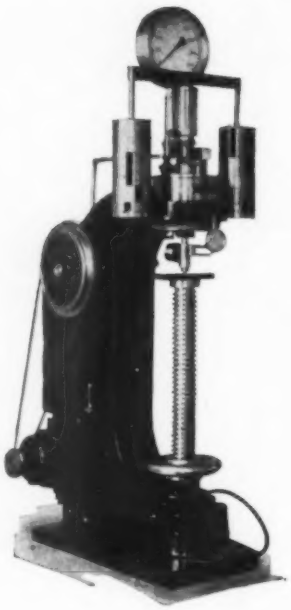

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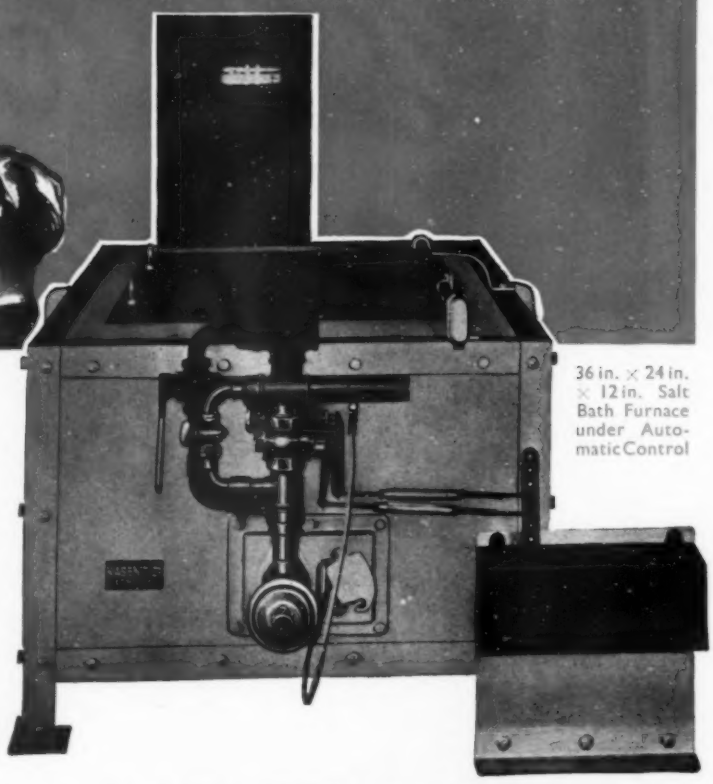


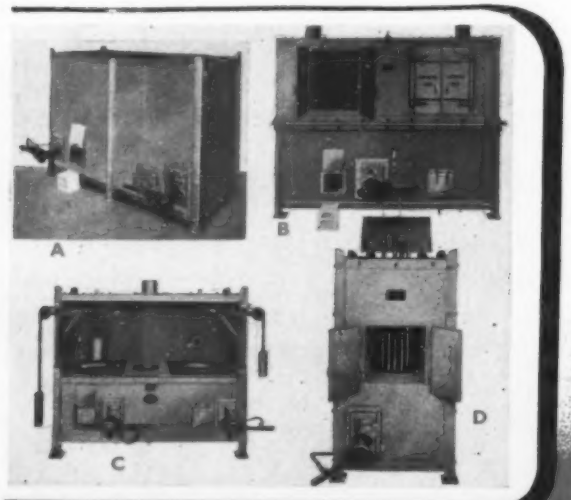
36 in. × 24 in. × 12 in. Salt Bath Furnace under Automatic Control

The design and construction of Kasenit Furnaces provides absolute control of all heat-treatment processes, including special purpose furnaces for all fuels. Furnaces are also designed to cater for any specific heat-treatment requirements.

There is a large range of Kasenit Cyanide Furnaces, both standard and special units, and in which the special design of combustion chamber and burner ensure long pot life.

This company are the largest manufacturers of case-hardening compounds in Europe, with 30 years' experience in the manufacture of products which have gained an enviable reputation.

To maintain that absolute control, as well as final quality, which is imperative today, use Kasenit No. 6 Repeating Compound. This compound is specially manufactured under strict control to ensure absolute uniformity and is the lightest compound marketed for case-hardening, weighing 20 lb. per cu. ft. It can be used repeatedly without addition of new material; contains no coke, leather, anthracite, or bone, and is free from dust. A large range of compounds is manufactured, catering for the special needs of particular processes.



A 15 in. dia. × 36 in. deep Twin Cyanide Furnaces for camshafts.

B 18 in. dia. × 12 in. deep. Cyanide Furnace with preheater.

C 10 in. dia. × 12 in. deep. Twin Pot Cyanide Furnace with central preheater.

D 10 in. dia. × 12 in. deep. Cyanide furnace suitable for long bars.

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advance on all other cutting oils

Photograph showing a mer being ground with Sternopal.

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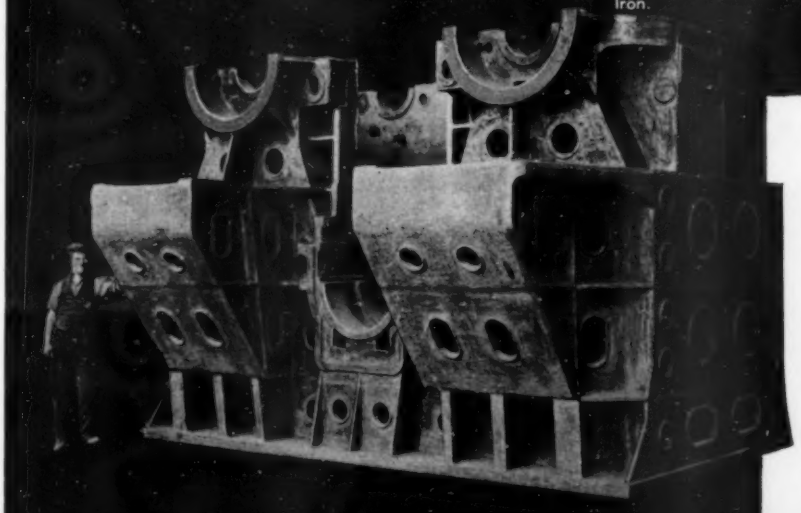
WHICH IS CORRECT ?

This picture is of

(a) Gun mounting for Swiss Navy.
(b) Section of Gruyere cheese.
(c) Harmonica Vaudevillenalis.
(d) 35-ton Cast Iron Gear Case from Armstrong Whitworth New Process Iron.



You're right ! It is another example of the excellent close-grained porosity-free high strength castings you get when using Armstrong Whitworth New Process Refined Iron. All New Process Iron is microscopically examined and a photomicrograph is attached to the analysis certificate. A guaranteed analysis and a guaranteed structure ! Write for illustrated brochure about "New Process Iron." "Armstrong Whitworth New Process Iron."

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What is SHARPAFORM ?

STAG SHARPAFORM form - relieved cutters represent the embodiment of a revolutionary method of relieving, the invention of Mr. M. Challier, patented under No. 410,677. For this patent Edgar Allen & Co., Ltd., have the sole rights for the United Kingdom, the British Empire, and certain other countries. The tools are made from Stag high speed steels under licence by the Stalker Drill Works Ltd., Sheffield.

No Rubbing

This patent cutter ensures that the relief of teeth is achieved in such a manner as to overcome one of the greatest present disadvantages of form-relieved cutters, namely, their propensity to rub, or failure to cut freely.

Constant Form

Form-relieved cutters made with the Sharpaform patent relief have increased cutting clearance with constant form. *Rubbing is entirely eliminated and a strictly constant profile* maintained. This combination spells increased production with accuracy.

Other advantages obtained by means of the Sharpaform principle are reduced wear on the machine, less power required, greater feed and speed, and a minimum of strain.

Advantages of SHARPAFORM

FORM-RELIEVED CUTTERS

1. **Greater production—more pieces produced between grinds.**
2. **Freer cutting—Rubbing eliminated —less power required.**
3. **Longer life—Tools will stand more re-grinds.**
4. **Absolutely constant form.**
5. **Greatly reduced cutter cost per piece produced.**
6. **Made from Stag high speed steels, produced in the high frequency electric furnace.**

Write for Stag Sharpaform folder

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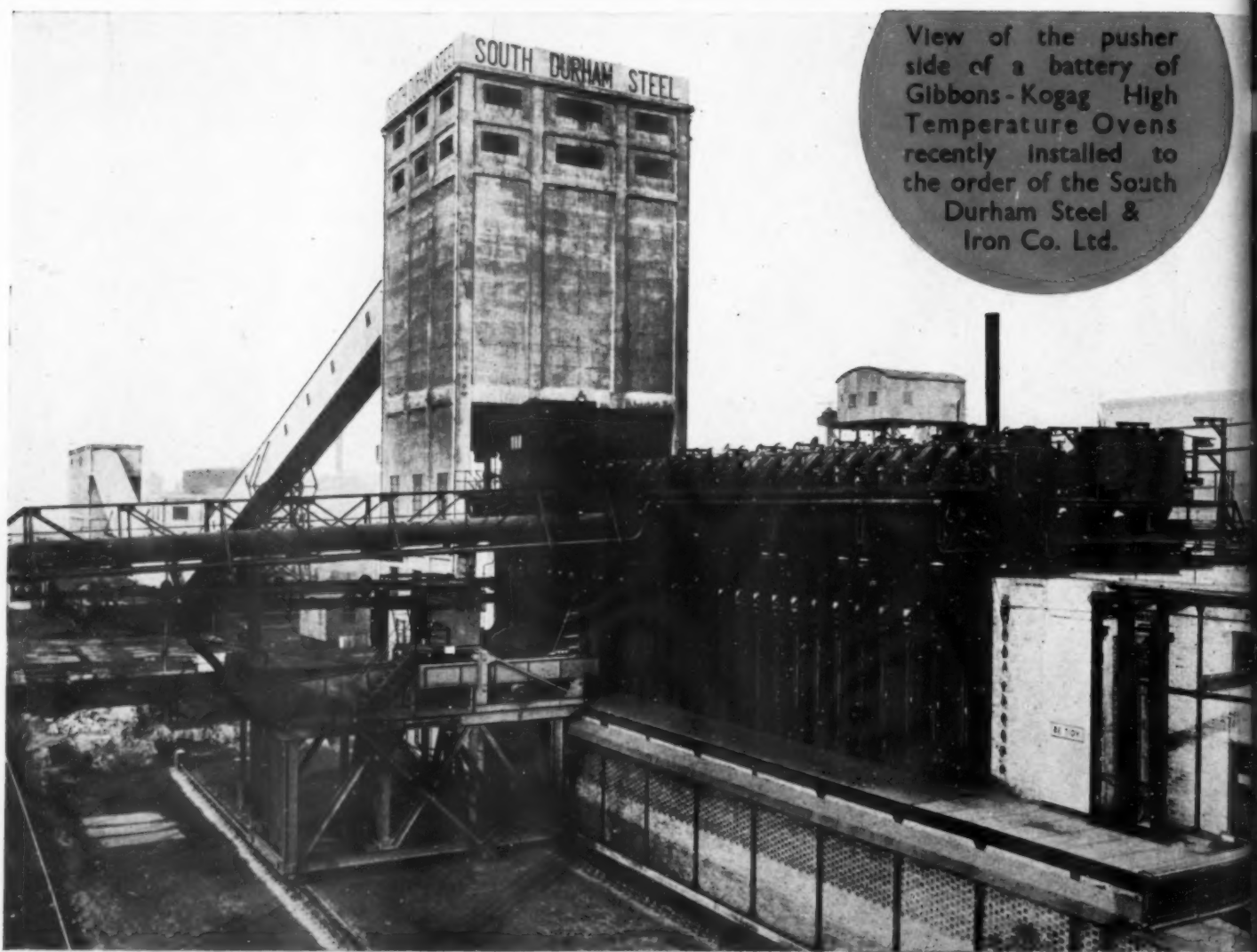

View of the pusher side of a battery of Gibbons-Kogag High Temperature Ovens recently installed to the order of the South Durham Steel & Iron Co. Ltd.

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KOGAG

OKE OVENS

Detailed view of 30 Gibbons-Kogag High Temperature Coke Ovens at Seaton Carew, showing self-sealing doors cross-over main and governor control, also combined pushing and levelling machine.

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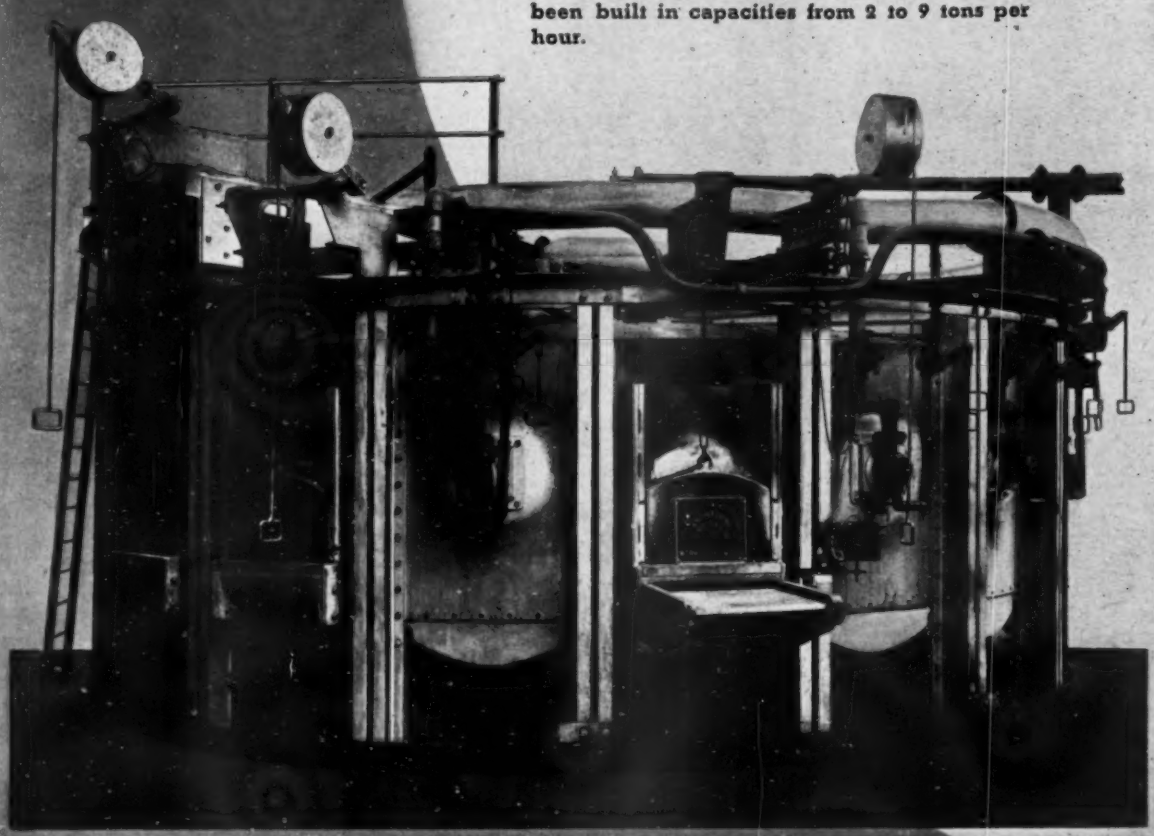
Rotary Hearth Billet Heating Furnace fired with coke oven gas through "Basequip K" Burners.

The billets are laid on a revolving hearth so spaced that three surfaces are simultaneously heated, assuring thorough soaking.

The Wellman Rotary Hearth Furnace has been built in capacities from 2 to 9 tons per hour.



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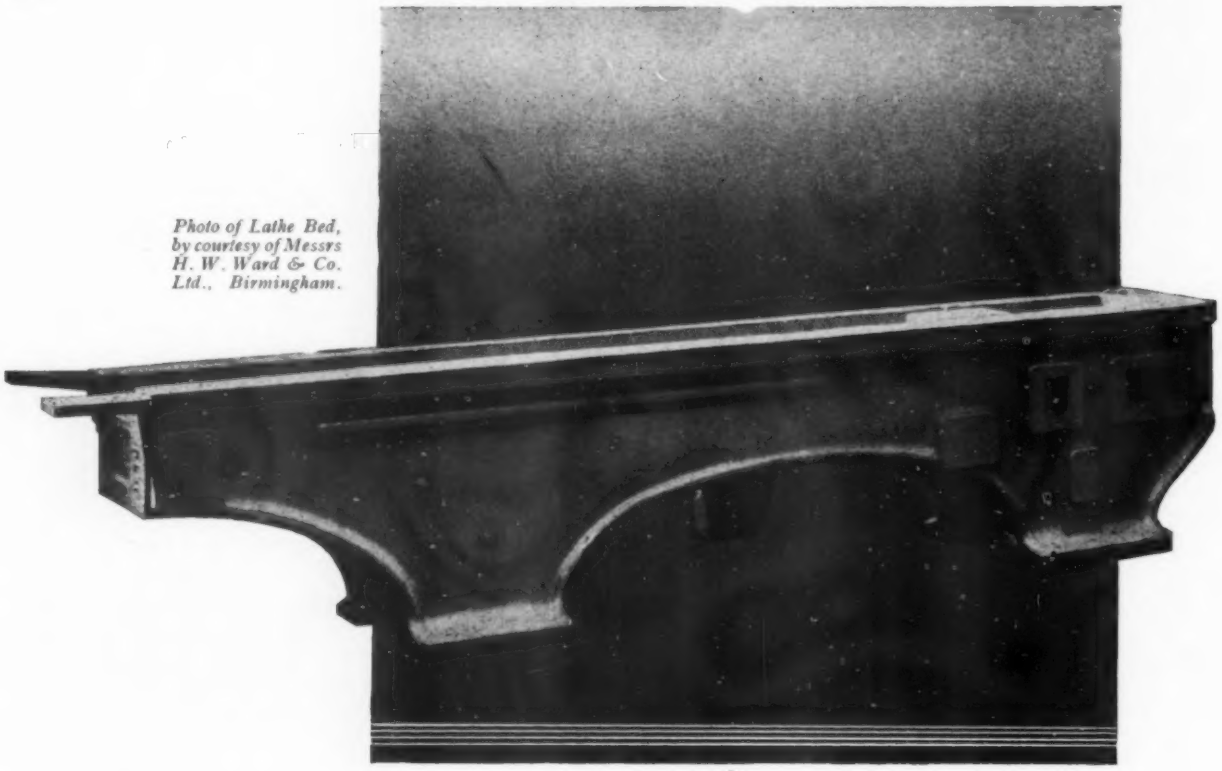

Photo of Lathe Bed, by courtesy of Messrs H. W. Ward & Co. Ltd., Birmingham.

● Our modern equipment and up-to-date organisation enable us to produce the highest quality castings, that are reliable, accurate, have easy machining properties and can stand up to long service. We supply small light section castings and the heaviest machine tool and other castings up to 10 tons.

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CAPACITIES ONE TO TEN TONS

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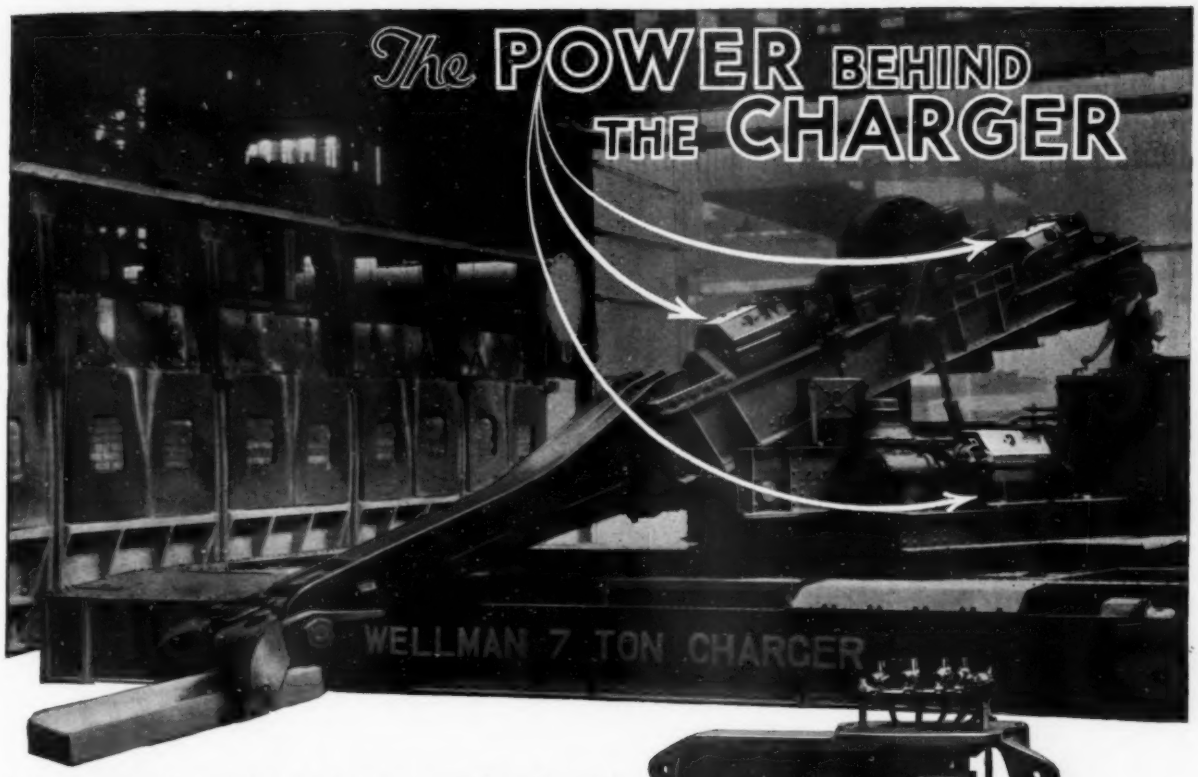
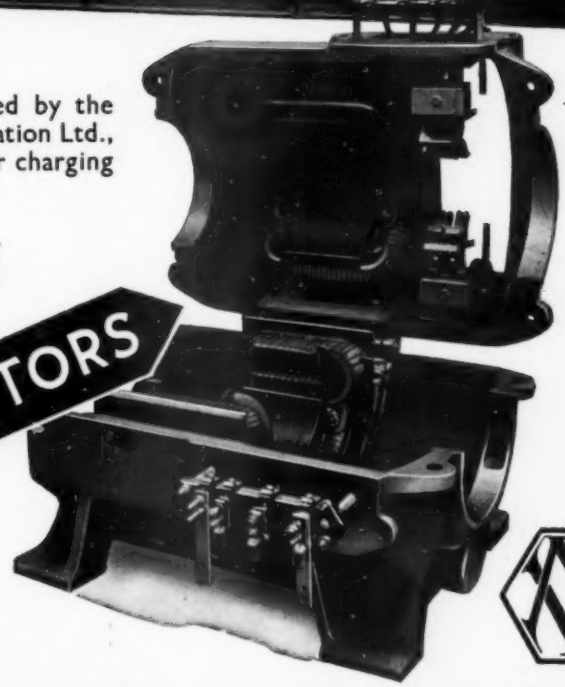


A low ground, revolving charger, supplied by the Wellman Smith Owen Engineering Corporation Ltd., to the Park Gate Iron & Steel Co. Ltd., for charging 7-ton slabs into Reheating Furnaces.

The machine is powered by means of SIX METROVICK TYPE MX MOTORS



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Specially designed for heavy duty in steel works.

The Charger has 5 separate motions as follows :—

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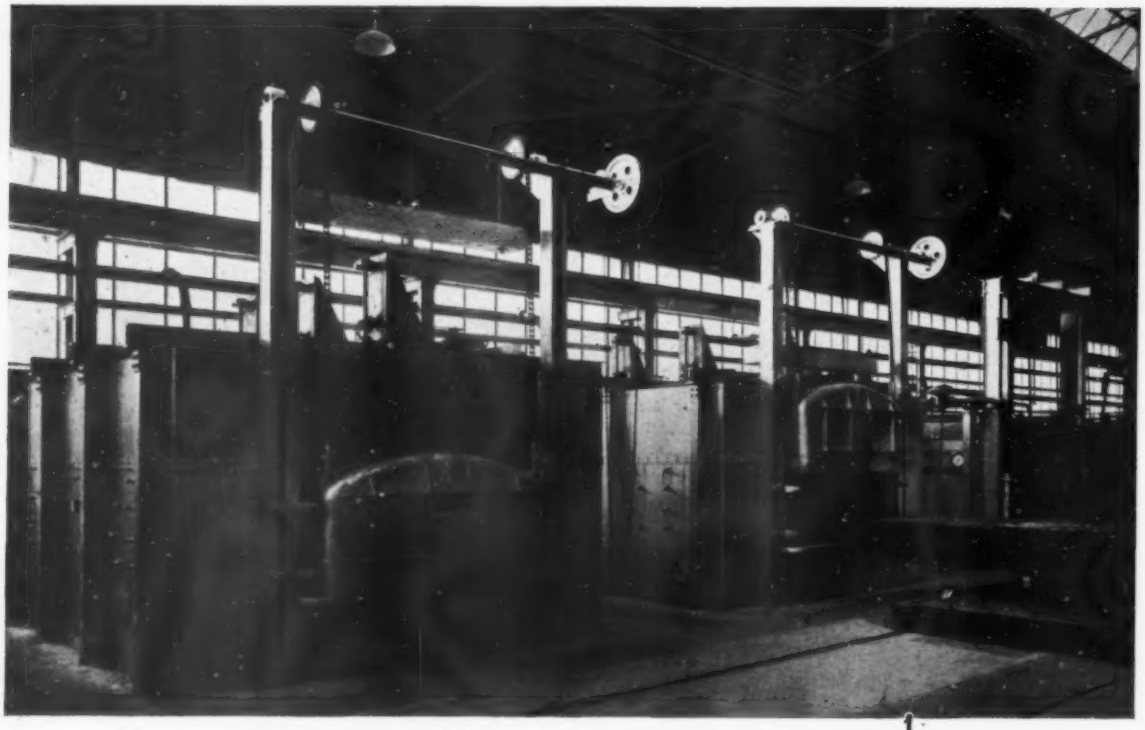

The above illustration shows a battery of Gas Fired Muffle Furnaces for Annealing Light Alloy Sheets.

Reliable results sought in heat-treating practice depend upon the proper combination of the man, the furnace, and the material. Good material is entitled to proper treatment in good furnaces, and both should have the services of good men.

No two cases are alike, and no type of furnace has a monoply on uniformity of heating or economy in operation; for this reason we, as specialists, design heat-treatment furnaces to suit your particular conditions and products; in this way reliable results can be assured, with the utmost economy.

For all types of burners and small heat-treatment furnaces
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TGS

Two "Super" Type Gas-Fired Oven Furnaces installed for reheating purposes by a well-known firm of Automobile Engineers. Furnaces of this type are ideally suited to all classes of heating and heat treatment operations.

Four Fan Recirculated Atmosphere Low Temperature Furnaces installed for the annealing of aluminium alloy sheets. In the foreground may be seen a patent Incandescent electrically-operated charging machine having a reach of 18' 6".

A Gas-Fired Vertical Furnace for normalising and tempering of railway wheels and tyres. Normalising is carried out at 800/850° C., and tempering at 600° C. An excellent example of an Incandescent special-purpose furnace.

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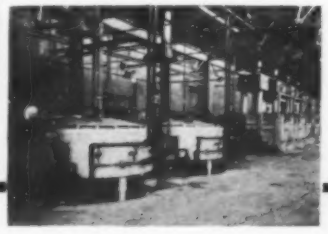
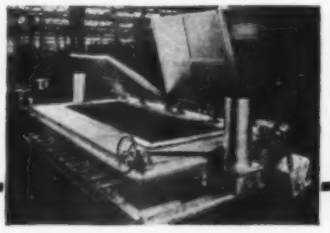
We manufacture furnaces for every purpose and for every industry, from small bench type furnaces to large sheet mill installations covering a range of processes which include annealing, normalising, carburising, hardening, tempering, salt bath treatment, etc. Some idea of the diversity of these manufactures may be gained from the illustrations.

Our Smethwick Works are modern and extensively equipped, incorporating iron, steel and alloy foundries ; machine, erecting, steelwork, welding and sheet metal shops ; physical and research laboratories.

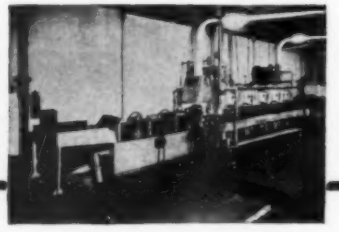
Adequate facilities are provided for the complete manufacture of furnaces and equipment, and our thirty-five years' experience in this sphere places us in a unique position to advise you on your particular problems. May we send further details and catalogues?



Two Rotary Roller Hearth Furnaces, fired by town's gas, for the hardening and tempering of automobile gears. Designed to give a machine-like heat treatment in the most compact floor space, with simple operation and control.



Incandescent Salt Bath Furnace, with a bath 11' × 4' 6" × 1' deep, for the treatment of Duralumin and light alloy parts. Note the simplicity of the door operation giving clear access to bath.



Roller Hearth Furnaces—the very latest practice in continuous heat treatment—suited to all classes of operations. A large number of these furnaces are now in operation in industries throughout the country.

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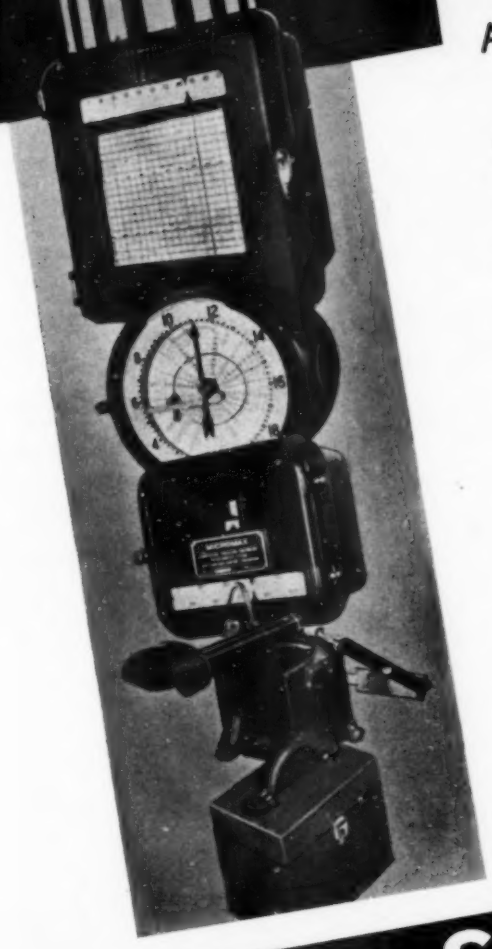

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There are L & N instruments embodying these principles to indicate, record and control temperatures for all types of furnaces and treatments, for remote operation, for multi-operation of furnace batteries or dispersed temperature locations and all these L & N instruments are robust machines built to laboratory exactness.

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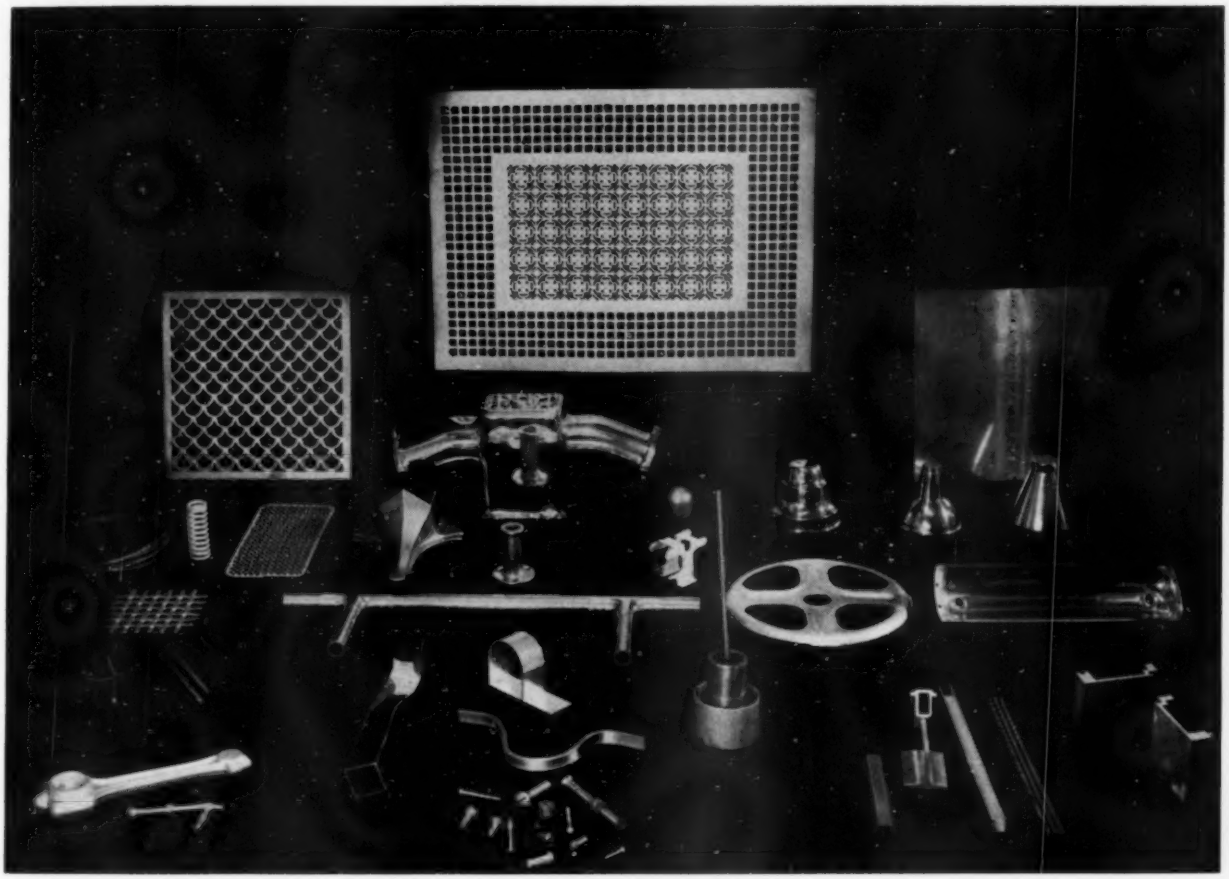
GRANGE MILL LANE, WINCOBANK, SHEFFIELD

Make it in **BIRMABRIGHT** REG'D.



THE facility of fabrication for products in "Birmabright" is well exemplified in the group here illustrated. The photograph shows sand and gravity die castings, spinnings, pressings, wire work, forgings, tubing, extruded and drawn sections, welded sheet, sections drawn on wood, nuts, bolts and rivets. Send for details now.

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the light, clean, corrosion-resisting alloy

BIRMABRIGHT LIMITED (A Component Company of Birmid Industries Ltd.)

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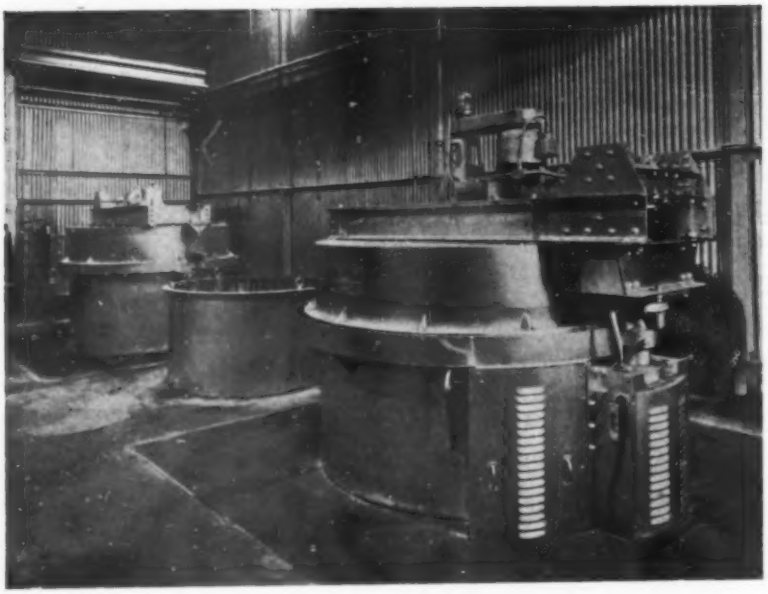
EFCO Furnaces for the Light Alloy Industry



Typical EFCO vertical forced air circulation furnace for heat treatment of light alloy castings.

We are manufacturers of furnaces for the melting and heat treatment of aluminium and light alloys for the production of sheet, strip, extruded sections, forgings, castings, etc., and amongst the users of our furnaces are the following Companies:

James Booth & Co. (1915) Ltd.
The British Aluminium Co. Ltd.
Northern Aluminium Co. Ltd.
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EFCO

ELECTRIC FURNACE COMPANY LIMITED
ELECTRIC RESISTANCE FURNACE CO. LTD.
17 VICTORIA STREET, LONDON, S.W.1

TELEPHONE ABBEY 4171 (7 LINES) **TELEGRAMS ELECTRIFUR, PHONE, LONDON**

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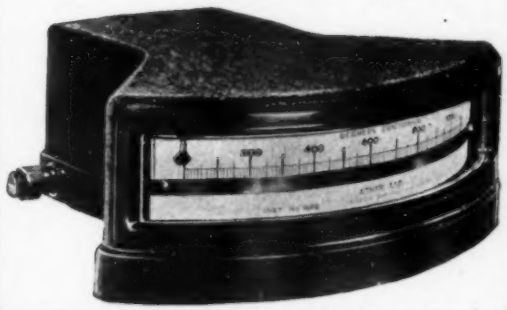
ETHER INDICATING PYROMETERS



The popularity of this class of instrument is its own indication of success. Made in three sizes and covering temperatures up to 1,600° C., it is fitted with mirror scales and knife edge pointers to enable fine, accurate readings to be taken. Many other exclusive refinements for accuracy are embodied.

Send for List No. 136. It describes this pyrometer in detail.

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Manganese Bronze. Yellow Metal. Naval Brass. Gun Metal.
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—To Be Continued

WE take this opportunity of stating that our announcements will continue to appear in this and other Journals as usual . . . thus not only fulfilling our contracts with the Journals but making our contribution towards maintaining employment in the Printing and Publishing Trade. In ensuing announcements we may touch unusual themes — as also (we hope) your pockets from time to time on behalf of some deserving National Charity. But whatever the topic — we think you will find it of interest to look for and read "what REYNOLDS have to say" about things.

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DISTRIBUTION SYSTEM
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...and here really IS

STRAIGHT LINE

Temperature Control

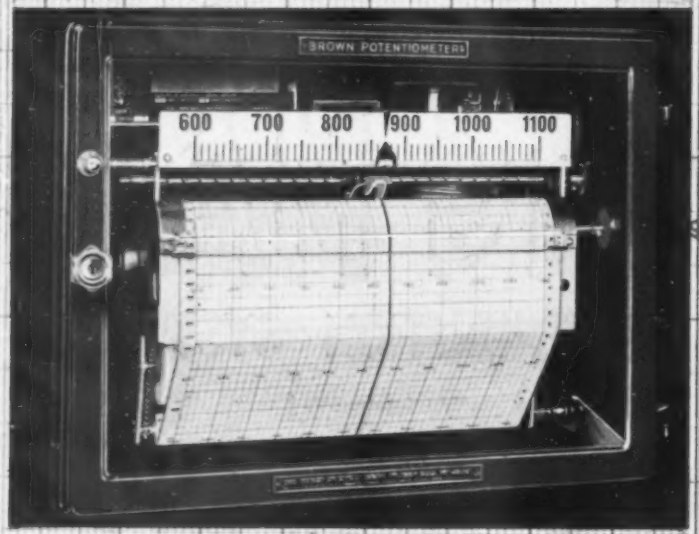
– an actual chart from the

EBBW VALE WORKS OF RICHARD THOMAS & CO.,LTD

At "Ebbw Vale," rigid control to ensure uniform high quality of production is the unvarying rule. This chart from a Honeywell-Brown Potentiometer Pyrometer shows the records of two points in an annealing cover at these works. The black record is the material temperature—controlled to any desired temperature with no undershooting or overshooting. When this temperature wavers by a fraction of a degree the variation is measured by the pyrometer, which controls an H.-B. motorised valve. This in turn automatically and instantly proportions the supply of gas and air to the burners to correct the variation before it can develop, and holds the material temperature to the line. The grey record shows how the burner temperature fluctuates owing to this action of the motorised valve.

This is the system that

PREVENTS OVERSHOOTING & UNDERSHOOTING



. . . . the Honeywell-Brown Potentiometer Pyrometer and (right) the H.-B. Motorised Valve. H.-B. Pyrometers are available to control, record and indicate temperatures from 0°-3,000° and all have charts 12" wide. At "Ebbw Vale" many H.-B. controls and instruments are installed.

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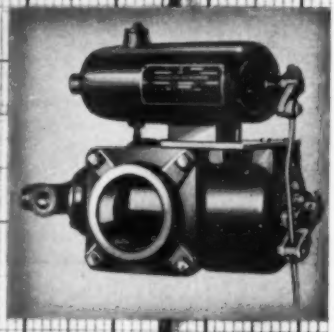
absolute uniformity of production -fewer rejects – lower fuel bills



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METALLURGIA

The British Journal of Metals
(INCORPORATING THE METALLURGICAL ENGINEER.)

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WAR !

WAR ! and the only sublime thing about it is the bearing of the average British man and woman. But war blurs so many things, including its own objectives, and before the heat of the struggle interferes with our vision it is worth while to record the goal for which Britain and her Allies strive. No dynastic ends are sought, no territorial changes, no gold, and no new supplies of raw materials. It is not the spoils of war that this country and Empire seek to win. We are fighting for something that is fundamental, that is beyond human valuation : we are fighting to defend moral values—liberty, good faith between men and nations, justice to strong and weak alike, the pledged word, and the common decencies of what we regard as essential in civilised countries. We can view the cause of hostilities with calm minds and untroubled conscience, for we feel that these values should not be allowed to perish.

The beginning of the present struggle differs from all previous conflicts perhaps in one important respect—the attitude of the people of this country to the people of the enemy country. In Britain the feeling is that we are at war with a comparatively few people in Germany. Our attitude to the German people is most friendly, and it has been particularly noticeable on this occasion that there has been no flag-waving or trumpet-blowing in the early days of the war, but just a grim realisation of the seriousness of the need for exterminating a something that is called aggression, and is symbolised by the present Nazi leaders in Germany.

The British public has refrained from cheap heroics ; there have been no public emotional orgies, and, as far as we know, apart from one or two sensational newspaper utterances, which can be discounted, no senseless hate expressed anywhere in this country. We are behaving therefore like the people we always congratulate ourselves on being. It is clear, from the attitude of British people, that we are fighting for moral principles, and it seems that we shall go on defending these principles as long as we are great as a nation. Striving for the maximum of human freedom and material progress is the desire of all peoples, as distinct from that of aggrandising rulers.

For the past two years war at some date seemed inevitable, but history will record that the British nation did all it could, while retaining honour, to avert another war, and whatever the future may hold in store for Mr. Chamberlain, it will be recorded that he was, up to the last minute, a man of peace, and that when he, as the leader of the Government, announced that we were in a state of war with Germany he could do no other.

Fortunately, in this conflict, we have not been caught unprepared, as in 1914. This time our land, sea and air forces are excellently equipped and well manned. Of equal importance is it that our metallurgical and engineering industries were also in a position to enable them to make the necessary changes from peace work to armament work, or to other work of national importance, with the least possible delay. The men in the metallurgical industries, whether in an executive capacity or occupying a more humble position, will wage this war with the sure knowledge that it is a righteous war against oppression, and for freedom, and with the knowledge that the scientific and technical fitness of this country is not surpassed by any other country.

As during the last war period, work at the national and private laboratories will be intensified to ensure adequate support for the forces, in whatever field they operate. This work is of vital importance. Mechanised units are now essential to modern warfare, and their successful use depends upon the maximum efficiency of each component, the question of determining the most suitable material of which it is to be composed, and in maintaining a high standard of manufacture, will have an important influence on the progress of hostilities. In the workshops, too, the necessity for a high standard of workmanship is not less important. In the last war Britain was slow in mobilising her maximum effort. With proper co-operation that is not likely to happen again, and, as a result, there may be a more speedy return to sanity by the Nazi regime.

Technical Meetings

The outbreak of war has upset the plans of the Iron and Steel Institute and the Institute of Metals, which were to have held their Autumn Meetings at Cardiff and Glasgow, respectively. Considerable disappointment will have been felt in both these cities because the work of organising the meetings had been in progress for some time, and the members of the respective Institutes in each city had been looking forward to the successful fruition of their efforts. These Institutes seem to be very unfortunate, for it will be remembered that in September last a combined visit to Canada and the United States was cancelled, almost at the last minute, due to the precarious international situation at that time. On the present occasion the position was much more serious, though the cause was practically the same, and there was no alternative to cancellation of the meetings. We are permitted to summarise the papers which would have been presented at these meetings in this issue. Brief descriptive references are also made to some of the works which were included in the programme of visits from each centre. Although these references will not fully compensate for personal visits that may have been intended, it is hoped they will prove both interesting and informative.

Another important meeting has been postponed as a result of the international situation—the Aluminium Congress, which was to have been held at Zürich this month. It has been suggested that this may be held next month, but we are not optimistic enough to believe this is possible. But the results of considerable research work on aluminium and its alloys, as well as developments in practice, have been prepared for this Congress and it is hoped that this will soon become available to assist industry by their application. The Engineering Exhibition, which was to have been held this month in London, is another function which has been cancelled in the national interest.

It is to be expected that normal peacetime activities would cease on the outbreak of hostilities of the present character, but efforts should be made by the technical institutes to preserve opportunities for meeting to discuss problems in their respective spheres.

Business as Usual

Our Policy

DESPITE conditions resulting from a state of war, we have endeavoured to refrain from adopting panic modifications to this issue, believing that the journal serves a national purpose. Although our staff is engaged on other part-time work, in which all loyal citizens are co-operating, we shall continue to serve the interests of the industries within our field with the same enthusiasm as in the past.

Readers will be particularly interested to note that the firms making use of our journal as an advertising medium are, with few exceptions, continuing to do so and to maintain a policy of " business as usual."

Germany's Navy

Submarine Total Obscure

APART from the present activity of submarines, which will be substantially reduced in a relatively short time by the action of the British navy, it is extremely doubtful whether the German navy will play any part in the present hostilities. It is of interest, however, to endeavour to gauge the strength of these forces. The two largest units of the German navy to-day are the battle-cruisers *Scharnhorst* and *Gneisnau*, both completed in the early part of this year. They are ships of 26,000 tons, with a designed speed of 27 knots, said to have been exceeded on trials, armed with nine 11-in., 12 5.9-in., and 14 4·1-in. anti-aircraft guns. They carry four aircraft with two catapults.

Germany is building two 35,000-ton battleships to be armed with 15-in. guns, but these are unlikely to be completed until late in 1940. A third has probably been laid down. The so-called " pocket battleships," *Deutschland*, *Admiral Scheer*, and *Admiral Graf Spee*, completed between 1933 and 1936, have displacements of 10,000 tons, with armaments of six 11-in., eight 5·9-in. and six 4·1-in. anti-aircraft guns. They mount eight torpedo tubes and carry two aircraft apiece. With a full speed slightly in excess of 26 knots they carry 1,000 tons of oil fuel, which gives them an endurance at economical speed of about 10,000 miles.

No German aircraft-carriers are yet completed, but two of 19,250 tons and 32 knots speed are in process of construction. One of these ships, the *Graf Zeppelin*, was launched at Kiel in December last. In various stages of completion there are five 10,000-ton German cruisers armed with eight 8-inch and twelve 4·1-in. guns. There are four cruisers of 7,000 tons, to be armed with 5·9-in. guns, under construction, and six cruisers of round about 6,000 tons are completed.

Ten large destroyers of 1,625 or 1,811 tons, with five five-in. guns and eight 21-in. torpedo tubes, were commissioned for sea during 1938, seven being already in existence. More are probably now completed. So far as is known, the eventual total in this type of vessel will be 30. Germany had a dozen small destroyers of 800 tons completed at the beginning of this year. She had building or projected 30 others, so the present total may be around 30.

The submarine total is necessarily rather obscure. In December last, when she announced her intention to build up to parity with the total British submarine tonnage, she was believed to possess 71 U-boats, completed, building or authorised. Of these 32 were coastal craft of 250 tons, 15 were of the ocean-going class of 740 tons, and 24 of the sea-going type of 500 tons. If Germany built up to the then British total submarine tonnage she had an extra 43,000 tons, of which to avail herself. She abrogated the Anglo-German Naval Treaty in March last, so it is impossible accurately to state the number of U-boats or their types.

Correspondence

Treating of Cast Iron with Caustic Soda

Sir,—In the August issue of *Metallurgia* you make reference to work carried out under the above heading at the University of Minnesota by Joseph, Scott and Tenenbaum. A warning should be issued lest any one should venture to carry out such experiments with caustic soda without appreciating the precautions which must be taken to avoid serious personal injury.

Caustic soda rapidly absorbs water if it is exposed to the atmosphere. In a wet condition it might cause an explosion when plunged beneath the surface of molten iron in the manner suggested by the three American workers. Even if kept dry the " violent turbulence " which occurs may cause caustic soda to be splashed on to the skin of the operator.

The fact that all the improvements in cast iron claimed for caustic soda treatment can be obtained more cheaply and without danger by treatment with sodium carbonate, suggests that the use of caustic soda is superfluous ; and, in any case, the technique recommended by the American workers could not be conveniently applied to large volumes of iron such as are tapped from modern blast furnaces ; but these are treated with sodium carbonate as a matter of general routine. Any one who has witnessed such treatment will realise, too, how misleading is the statement in your article that " the reactions are largely confined to points of contact between the top surface of the metal bath and the reagent or alkali-bearing slag." Sodium carbonate in contact with molten iron evolves carbon dioxide and this, together with the stirring action of the stream of metal entering the ladle, ensures the intimate mixing of soda slag and metal.

Yours faithfully,

N. L. EVANS,

for I.C.I. (Alkali) Limited

Northwich, Cheshire.

August 26, 1939.

British Foundry School

The following students are awarded the Diploma of the School following the work and examinations for the session 1938-1939.

The list is issued in alphabetical order, and is not divided into classes. Distinctions may be awarded in each of the four subjects of the examination—Foundry Metallurgy, Foundry Technology, Foundry Management, Foundry Casting Studies and Planning (Ferrous and Non-Ferrous). John Birchall (Horwich), John Victor Chatterton (Birmingham), Leonard Clarke (Willenhall), Victor Dennis Griffiths (Birmingham), Philip Hector Lawrence, B.Sc. (Bristol) (Derby), Edmund John Ludlow (London) (Distinction in Foundry Technology and Foundry Casting Studies and Planning—Ferrous), William Leonard Proctor, B.Sc. (Hon. Manchester) (Birmingham) (Distinction in Foundry Technology, Foundry Management, Metallurgy), V. S. Ganesh Rao (Jamshedpur, India), William Roberts (Adlington, Lancashire), Frank Warren Rose (Leeds), Frederick Warren Taylor (Walsall), Bernard Henry Trenear-Thomas, B.Sc. (Eng. London) (Birmingham), Charles Henry Wilson (Nottingham).

Mr. E. J. Ludlow, whose name appears in the Pass List above, has been awarded the first of the Fellowships recently established by the Worshipful Company of Founders, for the purpose of providing further facilities for training to men of outstanding talent.

In view of the outbreak of war, the governing body, with the approval of the Board of Education, has decided to close the school until further notice. The arrangements for opening the session on September 19 are therefore cancelled, and due notice of future reopening will be given.

Industrial Management and Production Control

Part X.—Planning and Progressing.

By F. L. Meyenberg

Planning and progressing are defined, and the method of carrying out the operations is discussed under various sections, such as analysis of orders, works orders, work and time studies, and processing. An example of planning a rod and bar mill is given, and various influences on the planning work are discussed. The actual work of the planning and progressing organisation is described with the aid of illustrations.

WHAT is discussed in this article is often considered as one of the main, if not the most significant, features of modern management, in contrast with what was meant by management, say, 30 years ago. And to a certain extent that is true. On the other hand, one may say that this matter of planning and progressing actually arises from the fact that the manager has become more aware of his duty not to adopt a casual attitude to business events, or to leave improperly trained subordinates to make decisions, but to make his own forecast of business trends and prepare to meet any anticipated difficulties. There is also the feeling—and I think rightly—that executive ability and planning ability are so different, that only rarely is the power to do both in the best possible manner combined in one individual, and that allocation of these functions to two different persons would therefore be advantageous.

This is one of the problems connected with the question of the division of labour, in this case not of manual but of mental labour; and the difficulties previously mentioned as connected with this problem also occur in this case. We have already defined organisation as "the art of using the advantages of division of labour necessary in industry, and of simultaneously avoiding the disadvantages connected with it, as far as possible in the given circumstances,"* and here, in particular, the organiser has a difficult task in harmonising the many interests concerned. Special attention, however, is necessary, if it is not a new works where planning and progressing must be introduced from the start, but an established undertaking, perhaps grown up from small beginning to a considerable size with hundreds or even thousands of employees, where quasi "hereditary" privileges must be abolished, new positions as mediators between old ones created, and only too often new persons from outside must be drawn in, and who, apparently, take from the old staff some of their work, and therewith a part of their influence.

In these circumstances, because planning and progressing is such a difficult part of works organisation, it will be understood that it is the object of numerous suggestions: modern literature is full of detailed descriptions of "systems," introduced here or there with great success, and recommended for other cases. Long experience in industrial life has made the writer very cautious in accepting such reports as completely true. I have seen more of these "systems" broken down, partly or completely, than working satisfactorily, even if a "recognised authority" had created and introduced them. For devising such a system, and even introducing it, and bringing it to life in the works and keeping it operative are two completely different things. Nobody who is responsible for introducing a system of planning and progressing should overlook this fact. If he is not perfectly convinced of the final advantage, if he is not prepared to have sacrifices in the beginning and apparently continuously, if he is not determined to overcome all initial difficulties with quietness but firmness, and if he has not the authority to maintain his policy fully, he had better leave this matter alone; for nothing is more depressing for him and detrimental to his reputation, nothing incites more the mockery of his employees than those "corpses" of "tables of allocation," "boards of dates of delivery," etc., which one may see in so many factories, not as a guidance to the shop, but only as a useless picture of what has happened, maintained in more or less good order—mostly in a less one—because the "boss" has introduced them, without having afterwards the necessary interest or time, and without installing the right assistant to look after the "system" and analyse all the results which would be helpful to a real works manager.

I must add one remark to these introductory words before we begin the actual discussion of planning and progressing, a remark which I find necessary because of the realisation that so many people are not fully aware of what they are doing when introducing this measure. When moving a function from executive to administrative people they must, of course, increase the number of the latter, sometimes without diminishing the number of the former, because these can now fulfil their executive duties better than before, and the improved quality of goods produced brings about a greater demand and output; but even if the latter is not the case, and the ratio of the administration personnel to the executive increases, what does this often-complained "augmentation of the clerical staff"—as it is commonly expressed—matter if the total costs of the produced goods decrease, and the service to the customer is improved by quicker or more accurate delivery dates?

Besides this economic point of view another may be mentioned—perhaps not considered, or even acknowledged by all my readers: is not this development something at which we should aim with all means, increasingly transferring human labour from the manual to the mental sphere? That is the trend of modern engineering. The central power station may be mentioned as an advanced example, where men are only switching over this or that lever and are almost completely released from heavy manual work. Of course, in usual factories we are far from that stage; but the attentive observer can see this trend anywhere. What a hopeful outlook it is, bringing to the mind of the follower of industry the much-too-talked-of nonsense of the immanent evil of industrial development.

But let us go back from this "philosophical digression" to our actual topic.

Definitions

In spite of my aversion to definitions I feel it necessary to explain what is meant by the expressions "planning" and "progressing," for I have found that these words are variously applied by different people, resulting in dispute and misunderstanding. The following definition may not be accepted by some of my readers, and I would be grateful for any criticism or correction. In any case, however, they explain what I mean by these words in these articles.

* "The New Management." Macdonald and Evans. 1939. P. 25.

Planning means establishing a plan based on systematic studies of the existing plant and the work on hand; how and in which sequence this work should be carried out by the departments, taking into careful consideration the capacity of these parts of the plant. Progressing means forecasting the times for carrying out this plan. In both cases a comparison should be made, as far as necessary, between what actually has happened and what is planned and forecast.

Special attention may be drawn to the words "as far as necessary" in the last sentence. This comparison is meant only as a control, how far the original planning and progressing could actually be realised, why it was, in some cases, not possible to maintain the original purpose, and to draw from that experience conclusions for the future. The mere following-up of what has actually happened—an activity sometimes called progressing—is useless, not worth the money it costs.

It may now be clear that planning and progressing can be done successfully only when the capacity of all parts of the plant is known, which processes the work on hand has to undergo in each case, and what time each of these processes requires. I have to apologise for the elementary aspects in this sentence which many readers will consider superfluous. Experience has shown that that is not very often the case in practice.

Only two ways of ascertaining these figures are known—statistics based on former production and time studies. A third way, sometimes recommended, can only be used in rare cases and with extreme caution—i.e., using the figures of capacity given by the producer of the plant. These figures are too often based on experiments in the test-house of the producer of the plant, and may not be realised in the different circumstances in practice. The statistics can only be based on the first booking of material and wages in the shops, and are reliable only if this booking has been done with the necessary accuracy, as formerly explained.[1] It may be that some figures, as, for example, numbers or other characteristics of the machine used, are needed which are not necessary for wages or costs purposes. Such additions should not be forgotten. Time studies are certainly the most reliable way to find out all the basic figures, but they are often too lengthy for procedure to be based on them alone. It must be left to the man in charge of this work to combine the possible ways in the case in question in the best possible manner.

Carrying out Planning and Progressing

To deal with the actual operation of planning and progressing we should look back to the diagrammatic representation of the organisation of an industrial works, which was given in Fig. 2 in Part III of these articles.[2] There it was shown that "planning" is a department inserted between design and production—i.e., between the development of the form and the quality of the goods to be produced by work in the laboratory or on the drawing-board on the one hand and the actual manufacturing of these goods on the other hand. Simultaneously, however, this planning department forms a link with the commercial side of the undertaking, for the superficial subdivision given in Fig. 2 enumerates four sections of the department—(1) analysis of orders, (2) works orders, (3) work and time studies, and (4) processing. It will be necessary to explain more in detail what these headings really mean, for in doing so the actual carrying out of planning and progressing will be described.

Analysis of Customer Orders

The "raw material" which has to be treated by the planning department is represented by customers' orders as received by the commercial side. It is usual to enter them in an order book in sequence of receipt, and to characterise them by an order number which accompanies the order through all phases of their processing. There are many various kinds in which this "order book" and this "system of order numbers" can be organised, but that is outside the scope of this article.

Another very important question, however, arises straightaway which can be decided only in the special case in question—i.e., can the production mainly be a delivery to stock and the goods then be despatched from stock to the customers, or is it necessary according to the nature of the customers' orders chiefly to produce these orders independently, and to despatch these separately produced goods to the customers without using a warehouse for finished goods? The first will always be given preference in metallurgical works, as a great simplification of production results; but the question will always arise whether warehouse will require such an investment of capital that the costs exceed the savings due to simpler organisation and easier production. It needs a very careful analysis of the received orders to find the correct answer; an analysis which has to take into account all variables contained in these orders, and their frequency. Observation of the orders over a fairly long time, and a statistical collection in various groups according to these variables, will be necessary in order to find out whether sufficient orders of equal or at least similar kind can be expected, so that a stock production can be recommended. In metallurgical works these variables will be, *inter alia*, quality and quantity of the raw materials; quality, quantity and size of the finished goods; the type of finish and the tolerances required by different customers, etc. Very often—we may even say much too often—we will find a multitude of varieties which alone seems to make a stock production impossible. Standardisation has not been sufficiently understood in the circle of the customers, and the supplier is afraid of the work connected with the education, or afraid of losing a customer, if he does not agree without argument to the demands of the customer, etc. It is impossible to discuss this question in more detail in this article; but the unbiased observer must state, with regret, how large sums are lost by the lack of understanding between customer and supplier, so far as the question of standardisation is concerned, and that in spite of the deserving work of the British Standards Institution.

The solution mostly adopted is that of a mixed system: for some kinds of customers' orders a conversion into stock orders is made, i.e., for all those for which that is possible without increasing inadmissibly the disadvantages of the warehouse, and the other part of the customers' orders are treated as they are, i.e., the customer's order is used unchanged as a works order. This decision complicates the organisation considerably, but that must be permitted if the final result is a decrease of costs, which can only be decided in specific cases.

Summarising the analysis of orders, this part of planning can be defined as the systematic conversion of customers' orders into works orders, as best suited to the capacity of the plant under present working conditions, without neglecting the demands of customers as to quality, quantity and date of delivery of the finished goods.

Works Orders

When the number of works orders on hand are thus known, and for each of these orders are also known all details as to quantity, quality, size, kind of finish, approximate date of delivery demanded, etc., then the sequence of these orders has to be determined, and for each order a detailed working plan, showing which processes the material has to pass through, by which operations each of these processes is composed, which part of the plant has to be prepared for each process or operation, what labour is requisite, which tools, special jigs or gauges are necessary, etc.: in a word, the planning man has to envisage the total procedure of production in all details and to take care that the material, the plant and all necessary auxiliaries are at hand at each stage. This should be put down in writing, and such a specification, once established, can be used again when the same works order turns up. Gradually

[1] See METALLURGIA, Nov.-Dec., 1938, May, 1939.
[2] See METALLURGIA, Dec., 1938.

a collection of specifications will accumulate which will more and more facilitate the planning work, especially for repeat orders, mostly identical with those stock orders mentioned above. In the case of these repeat orders, it will be of great importance to investigate—maybe by special work and time studies—whether the most economical method of production has actually been chosen, where improvements are necessary, and how they are adopted, and with what results.

We touch here the next part of planning work, i.e., work and time studies, about which nothing more may be added as they are treated already to some extent in former articles of this series. But it leads, however, to the next and last part, "progressing," which is partly based on work and time studies.

Progressing

As may be remembered, progressing is defined as forecasting the times for carrying out the plan for the work. When saying that time studies should be used, it may expressly be added that sometimes, especially in starting a planning system, it may not be necessary, or even not advisable, to carry out these studies in the elaborate manner necessary for production control purposes, or when aiming for an improvement of a special production process. In this case the work to be done is so great that it may be sufficiently accurate to use a more superficial method, because it would otherwise take too much time before any results could be obtained. That may be allowed in some cases, but it must be remembered that a more superficial method contains a certain danger, as wrong time figures can misdirect the whole procedure. In any case, it needs a person well experienced in time study work, as well as in the special kind of production, to avoid such mistakes. Sometimes the time study method may even be replaced by statistics taken from past production, if one can be satisfied that the basic figures of such statistics, the first establishment of figures of time in the shops for wages and cost purposes, are accurate enough and that a fairly stable state of production has been obtained.

Additional Remarks

That may be sufficient to explain generally how "planning and progressing" should be carried out. Only two remarks may be added, although the second partly repeats in other words what is already said.

When planning is divided as above into four parts, and these are dealt with one after another, that does not mean that this procedure should be followed up also in practice. This division is made mainly for the purpose of easier explanation. Really the four parts are so closely connected with each other, at least the last three, that they have to be considered, and often dealt with, simultaneously.

Further, planning needs, first of all, *patience*. It takes months, sometimes years, from the day when it is decided to introduce planning to the date when the first practical results can be obtained, at least if the workshops in question are concerned with a fairly complicated production of considerable output occupying a lot of workmen, and only in such cases should planning be considered at all. The staff must be increased to do the preparatory work and will remain greater than before, even when the planning procedure has been introduced. This problem has been discussed already above. Therefore the warning may be justified; only he who, after considering all these circumstances, is sure that planning will be a definite advantage in his case, who has the energy, persistence and patience to carry out this job to the very end against all difficulties which may arise, and probably will arise, in works grown up without using this modern method, should really undertake it. It is much better to leave it alone than to stop halfway, and so to "lose face" somewhat before his workpeople.

To be continued.

Steels in Marine Engineering

IN the construction of marine engines, whether reciprocating, turbine, or oil engines, steel is utilised in varying proportions. In general, the quantity used is somewhere between 50 and 60% of the total weight of the engine, if the steel required for the boilers of the first two types of engines is included. In engine construction, all varieties of steel are now used, including low and high carbon steels, and low and high alloy steels, although the larger proportion is still steel of low carbon content in the form of plates, bars, forgings, and castings.

Standard boiler steels, both for fire tube and water tube boilers, are low carbon steels containing 0.22 to 0.32% carbon and having a tensile strength of 28 to 35 tons per sq. in., and an elongation of 20%. Bars for rivets and plates for flanging are specified to be 26 to 30 tons per sq. in. From such steels, having a range in any one case of not more than 4 tons per sq. in., are manufactured shell plates, girders, butt straps, staybars, drums, tubes, and wrapper plates. Where boiler pressures are higher than normal (200 to 250° F.), higher carbon steels of 36 to 42 tons per sq. in. tensile strength or 3½% nickel steel, are used for shell plates, wrapper plates, and drums, and recently, alloy steel boiler tubes have been introduced, containing 0.25 to 0.5% copper, 0.25 to 0.5% molybdenum. Alloy steels are not used, generally, in marine boiler work except for superheater supports and baffle plates exposed to flame temperatures, when non-scaling heat-resisting steels are employed. Steels of the 18/8 type with silicon, titanium, or tungsten, 28/18 or 35/12 nickel-chromium steel, or 30% chromium steel, gives satisfactory results for such parts. Certain studs, bolts and nuts are also made from alloy steels.

Carbon steels are used in marine engineering in the form of normalised forgings or bars and are usually classified, according to their strength, as 28 to 32, 31 to 35, or 34 to 38 tons per sq. in. carbon steels. The first class is used for crankshafts, crank webs, connecting rods, piston rods, bolts, valve and pump parts, shafting and propellers in reciprocating and oil engines, and for primary wheels, claw pieces, and the main shafting of turbines. Class two is used for similar parts, crankshafts excepted, in reciprocating and oil engines, where greater strength is required, and for main wheel rims, gear wheel shafts and discs in turbines; and class three for higher strength crankshafts and webs, connecting rod bolts, and shafting in the former engines and for rotor shafts, rotor wheels, rotor drums, coupling sleeves, and main shafting in turbines.

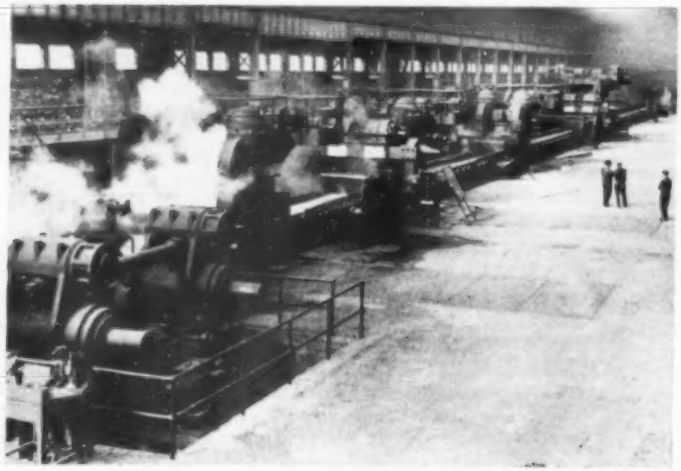
Steels of over 40 tons per sq. in. tensile, oil hardened and tempered, are sometimes used for connecting rods, crossheads, and fuel valve and pump parts in oil engines and case-hardened mild steel for gudgeon pins, cams, rollers, and fuel valve and pump parts in similar engines. Annealed cast steels of 31 to 35 tons per sq. in. are used for turbine casings for steam temperatures between 450° and 760° F. Where higher temperatures have been adopted, a low-molybdenum cast steel gives satisfactory results, due to its higher yield point and greater resistance to creep. Crank webs are sometimes made of 28 to 35 tons per sq. in. cast steel, and the same steel is used for cylinder covers, while a higher tensile cast steel of 35 to 40 tons per sq. in. is suitable for piston heads.

Low alloy steels of nickel (3½% nickel), nickel-chromium, or nickel-chromium-molybdenum, oil-hardened and tempered, are used in turbine construction for such parts as pinions; and in high-speed turbines, stainless iron is used in quantity for H.P. and L.P. reaction blades, and 32/12 nickel-chromium steel, containing tungsten, for H.P. impulse and astern blades. The latter steel and 18/8 steel, containing titanium, is also suitable for partition plates and nozzle vanes.

In addition to the former, large quantities of steel are also used in marine engine work, for valves and steam pipes, pumps, steering gear and auxiliary machinery.

Iron and Steel Production in South Wales

Probably no industry has suffered greater fluctuations than the iron and steel industry of South Wales. Concerned with the production of iron since early in the seventeenth century, South Wales has since been one of the main producing areas for iron and steel. Recently the need for more economical production has led to rapid development of works, some of which are briefly referred to in this article.



By courtesy of Richard Thomas and Co. Ltd.

A general view of the rough train at the Ebbw Vale Works.

THE production of iron in South Wales is a matter of, literally, centuries, and it can be said that iron formed the major factor in the economic development of that district until 1870. This continued until the first half of the last century, when that comparatively narrow 20-mile strip of coalfield, from Pontypool to Blaenavon and Hirwin, became the largest iron-producing region in the world. This production centred largely around the famous Merthyr-Dowlais pits and furnaces.

The demand for purer and richer ores, and the introduction of the Bessemer process for steel-making, influenced the location of the production area, and a drift towards the coastal region was soon established. The coastal steelworks developed the production of tin-plate and galvanised iron until, quite recently, more than 90% of the exports of British tin-plate were concentrated in Swansea port.

But as the needs of industry for more and better steel increased progressively, the steel-producing units were supplemented by more inland works, of which the great Ebbw Vale concentration of iron and steel industrial activity is an outstanding example. The writer well remembers the poverty prevailing in the Western and Rhymney Valleys in the 1923-24 period, due to the lack of activity at Dowlais and other centres, and can speak from personal experience of the depression—in every sense of the word—from which Ebbw Vale in particular suffered. The reorganisation of Ebbw Vale is one of the more-optimistic features of the recent industrial outlook, and now, with a national emergency calling for steel and steel products in great variety and quantity, South Wales should find its steel business heading to peaks previously considered unattainable ; and when hostilities hostilities eventually cease, the country should be able to absorb gradually any outstanding stocks and divert its steel production to other and more civilised uses.

The economical production of iron and steel in South Wales has made rapid progress in recent years, and in the following notes brief reference is made to developments at some of the works in this area which were to have been visited by members of the Iron and Steel Institute in connection with the Autumn Meeting, which was arranged to be held at Cardiff but has since been cancelled.

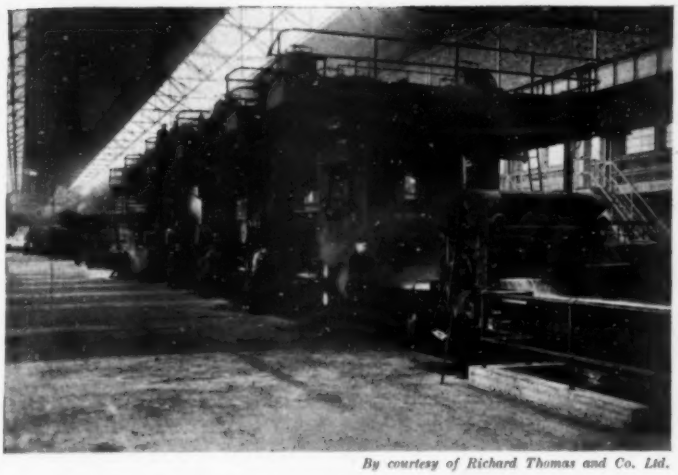
Richard Thomas and Co., Ltd., The Ebbw Vale Works.

EBBW VALE has been associated with the iron and steel industry since early days ; raw materials essential to manufacture are at hand, ample water power is available, and suitable transport facilities exist by land or sea. The industrial history of the valley in which Ebbw Vale is situated began with the inception of the Ebbw Vale Company on a site which had been acquired from the Earl of Pembroke. It is not possible here to dwell upon the fluctuations of the industry which was subsequently developed by the Ebbw Vale Steel, Iron and Coal Co., Ltd., but it was a bitter blow to the community when it was decided to close down the major part of the company's plant towards the end of 1929. By 1934 Ebbw Vale was recognised as one of the hardest hit in the industrial depression, The following year, however, the outlook became brighter when it became known that Richard Thomas & Co., Ltd., had decided to revive the steel industry in the Valley with new works, planned, constructed and equipped on the most modern lines.

The properties acquired by Richard Thomas & Co. covered a site nearly two square miles in area in Ebbw Vale ; also an iron-ore field in Northamptonshire, five collieries and limestone quarries. With the exception of the power station and boiler plant and small gasworks the whole of the former workshops of the Ebbw Vale Steel, Iron & Coal Co. were pulled down, so that the present works can be said to have been entirely constructed and put into operation since that time.

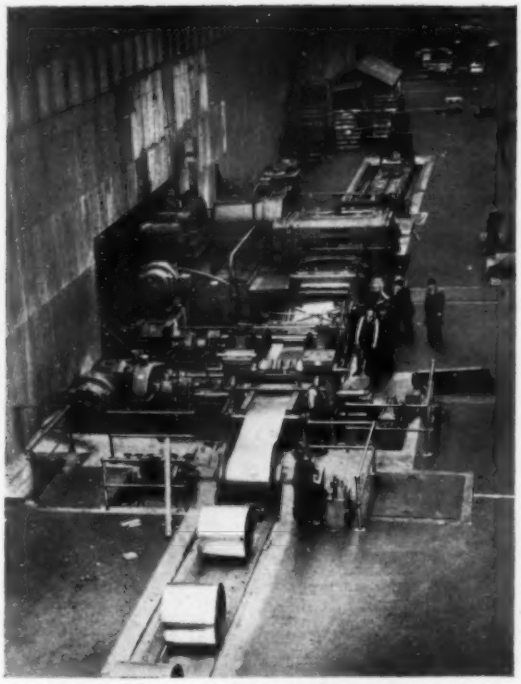
Primarily concerned with sheet products the Ebbw Vale Works is equipped with a continuous hot-strip mill (the first of its kind installed in this country) which is capable of dealing with slabs up to 52 in. wide. The whole is designed for a yearly output of 500,000 tons of sheet and tinplate of the highest quality.

The plant at these works includes sixty-five Becker coke-ovens, equipped with modern coal-handling, blending, crushing and storage equipment ; coke-screening and handling plant ; by-product recovery plant and benzole recovery plant. There are two blast-furnaces, each having a capacity of 3,500 tons of pig iron per week. Hot metal from the blast-furnaces is delivered direct to the steel-making plant ; manufacture is by Bessemer process, by open-hearth or by the duplex process, giving a wide range of sheet steels according to requirements. The steelmaking plant comprises three Bessemer converters, three Siemens-Martin open-hearth furnaces of the Venturi type, each of 75 tons capacity, and one mixer, with a potential output of 9,000 tons per week. The ingots, which may range up to 10-tons each, are transferred to soaking pits fired either by coke-oven and blast furnace gas, producer gas, or oil.



By courtesy of Richard Thomas and Co. Ltd.

The exit end of the five-stand hot-finishing mill.



By courtesy of Richard Thomas and Co., Ltd.

The sheet cut-up line, comprising a machine which operates at 350 ft. per min. side trimming, end shearing, and roller-levelling the material.

The most interesting feature in these works is the rolling mills; the hotmills extend in a straight line down the length of one huge shop 1,860 ft. long. The blooming mill is of the two-high reversing type, which is driven by a 7,000-h.p., 800-volt motor capable of operating on a peak load of 21,600 h.p. The slabs produced are sheared to sizes suitable for further rolling which either pass direct to the roughing mills and hot-finishing mills in sequence or are transferred to slab-heating furnaces from which they are drawn to meet the requirements of the hot mill. Careful attention is given to the slabs to ensure that the surface quality of the subsequent sheet will meet requirements, but, when the sheets must be of special surface quality, the slabs are cooled, their surfaces inspected and imperfections removed before they are converted into sheets.

The slab furnaces are 20-ft. wide with a heating length of 80-ft.; they are fired with mixed coke-oven and blast-furnace gases. The slabs are discharged on live rollers to the roughing mills, the first pass being given in a scale-breaker. The roughing train proper comprises three two-high stands and one four-high stand. Edging rolls are incorporated in the second and fourth stands, and separate drives are given to each of these processes, as well as to the main roughing mills.

The material passes on to the hot-finishing train, but, before it enters the first stand, its temperature must be controlled to obtain the required grain structure in the finished product, and low-pressure air jets are used to reduce the temperatures of the material, if necesary, before continuing the rolling. After passing through a two-high scale breaker the material passes through five hot-finishing stands, each of which are of the four-high type. If no special finishing processes are necessary, the sheet produced may be accurately sheared in lengths up to 32 ft. and automatically stacked, or the sheet may be coiled for greater ease in transport. On the other hand, sheets may be given the usual finishes. In some cases, coils of 12 to 18 gauge sheet are processed at this stage, the treatments including side and end shearing, roller straightening, pickling, normalising and reshearing.

Coils which are for cold-rolled sheet production are transported direct from the pickling line to a three-stand continuous mill which produces about 30 tons of finished material per hour. There also is a four-high mill, each stand having rolls 56 in. wide, the work rolls being 19-in. diameter and the back-up rolls, 49-in. diameter. In this mill, strip may be rolled to a minimum thickness of 0.015 in. When the material has been rolled to the required gauge it is delivered in the form of coils to the cut-up lines where it is side-trimmed, roller levelled, end sheared and stacked. Finally, the coiled strip is annealed.

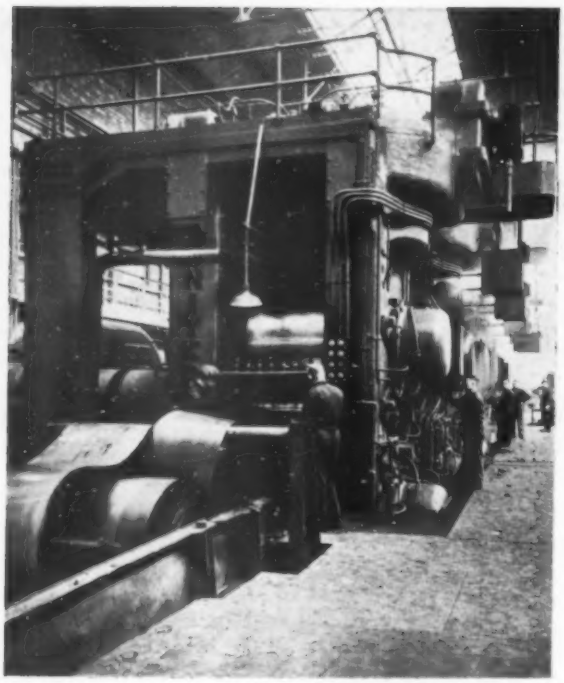
The sheet-finishing plant which is installed in the line following the hot-rolling process comprises a batch-type pickling wquipment, which consists of a 4-vat black pickler and a 3-vat white pickling apparatus. The 4-vat black pickler deals with sheets not required to be cold rolled or finished in other sections. The 3-vat white pickler deals with tinplate sizes only. The former has an approximate capacity of 20 tons per hour, the material usually treated ranging from 168 in. by 50 in. to 96 by 22 in.

Tinplate coils are taken from the pickling line to a five-stand continuous cold-reduction mill. As with the three-stand continuous sheet mill, these mills are of the four-high type. The minimum thickness attained by this mill is 0.0083 in. in widths of 20 and 30 in. Annealing, which may be carried out either in coil or sheet form, is done in Lee Wilson radiant tube furnaces fired by coke-oven and blast-furnace gases.

Extensive Equipment

The equipment associated with this plant is so large and varied that it is only possible to make brief mention here to some parts of this great enterprise designed for the production of sheets and tinplates of the highest quality, but not the least important of the auxiliary equipment is the centralised pressure oil and grease lubrication systems, the hydraulic descaling system, the roll contour control and roll cooling systems. There are seven large centralised pressure oil-lubrication systems which assure continuous lubrication to meshing gear faces and 450 bearings, each of which automatically receives the proper consistency and quantity of liquid lubricant by constant circulation and it is applied at a proper temperature. In addition to liquid lubrication, there are over 16,500 bearings which, because of temperature, speed or heavy load conditions, must be lubricated with a semi-solid lubricant. This is accomplished at Ebbw Vale by the installation of a highly specialised grease distributing system which automatically delivers the proper consistency and quality of grease at predetermined intervals.

One of the most important factors in the production of steel in the modern hot-strip mill is the quality of the product manufactured. To a very large degree this quality is primarily dependent upon the " intensity " of descaling which the strip receives during its conversion from slab to



By courtesy of Richard Thomas and Co. Ltd.

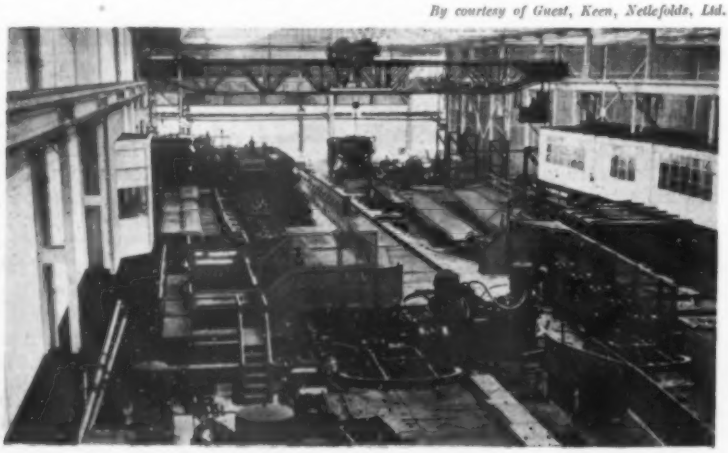
Entry end of the five-stand cold-reduction tinplate mills.

finished strip. Descaling of the steel, being rolled in the 56-in. hot-strip mill at these works, is accomplished both automatically and hydraulically by the installation of a modern hydraulic descaling systen. The basis of operation of this system is, first, cold water applied to hot steel having a surface of scale causes a reduction in temperature of the scale surface which results in shrinkage as compared to the main body of the steel. This slight shrinkage is, however, sufficient to form cracks in the scale surface allowing water to penetrate if applied under sufficiently high pressure. Secondly, high pressure water penetrating the cracks and encountering the main body of hot steel is immediately flashed into steam resulting in a tremendously increased volume which has a tendency to explode the scale loose from the main body of steel. Thirdly, high-pressure cold water scientifically applied in sufficient volume flushes away the scale which has been broken loose from the main body of the steel.

All the mills and complementary equipment in these works are the most modern in regard to mechanical design and the manufacture of the integral parts were carried out to extremely close tolerances to ensure a high degree of accuracy in the production of sheet and tinplate. These works are not only of outstanding interest and importance to the South Wales iron and steel industry but to the whole British industry.

New hot-strip mill at Castle Works, Rogerstone.

By courtesy of Guest, Keen, Netlefolds, Ltd.



Guest, Keen and Nettlefolds, Ltd.

AFTER operating in Rogerstone, Monmouthshire, for over 50 years, Messrs. Guest, Keen and Nettlefolds, Ltd., transferred their works to a site in Cardiff, adjacent to the heavy steel works of Messrs. Guest, Keen, Baldwins Iron and Steel Co., Ltd., in which the Company has a substantial interest. These new works, known as the Castle works, comprise bar and strip rolling mills, a rod mill, cold rolling mills, wire drawing mill, nail factory and chilled rod plant.

The reconstruction at Cardiff began with the erection of a continuous rod mill, capable of producing 3,000 tons per week of rod in 400-lb. coils, in sizes from 6-gauge to $\frac{9}{16}$ in. diameter. This mill is acknowledged to be one of the most efficient in the world. The speeds of the finishing rolls vary from 700 r.p.m. on 6-gauge to 500 r.p.m. on $\frac{9}{16}$ in. diameter. The speed is such that before the rear end of a billet has finally left the furnace the fore end has already become finished rod, and the process of coiling on the reel has begun.

The bar and strip mills are of the Morgan type, with a common roughing mill and separate strip and bar finishing trains, providing great elasticity and ensuring output under the most efficient conditions. Billets are delivered and stacked at the rear of the heating furnace of the hot mill, being delivered as required to a conveyer for charging. The heating furnace is of the Morgan continuous suspended-roof type, and has a hearth 32 ft. by 40 ft. for receiving billets 30 ft. in length. The capacity is 40 tons per hour of 2-in. or 3½-in. square billets. After leaving the finishing rolls bars are delivered on to a 270-ft. cooling bed, where they are cut to required lengths before being transferred to the bar warehouse or to the finishing departments, where bars for ferro-concrete work are bent and shaped.

Finished strip is received by a trough, which first places the material on edge and then carries it to one of a pair of motor-driven pinch rolls. Each of these co-operates with a vibrator and delivers the metal on to an apron conveyer. Four reels are situated at the end of this conveyer, and the coils formed are mechanically transferred to a chain conveyer, about 250 ft. long, for partial cooling prior to discharge into trucks or stock bay.

On completion of the hot-rolling process, the coils are loaded on trucks at floor level for transport to the cold-rolling department. The continuous-strip pickling plant is housed in a building 270 ft. long by 25 ft. wide, adjacent to the cold-roll strip mill, and is designed to pickle 300 tons of hot-rolled strip per week in any width up to 10 in. The plant is laid out in a straight line and consists of the following units: Uncoiling swifts, welder acid tank, 80-ft. long by 5 ft. wide; cold water spray tank, 6 ft. long; hot-water tank, 12 ft. long; drying furnace, 8 ft. long; bending rolls; rewinding coilers, together with acid supply tanks; pumps for emptying the acid tank and two cranes, one at each end of the building. each coil is placed on the uncoiling swift, then taken through the acid tank. On leaving this it enters the cold-water spray tank, then into hot water, to ensure complete removal of acid from the surfaces.

Leaving the hot-water tank the strip passes between a series of hot-air jets and then into the drying furnace, heated with blast-furnace gas, where all surplus moisture is removed. From this point the material is

taken by means of guide rollers to the bending rolls, which provide sufficient tension for coiling, and then to the recoiler drums which are 18 in. in diameter and will coil up to a maximum outside diameter of 40 in. The range of material which can be rolled includes all widths up to 10 in., and thicknesses down to 0·005 in. in all qualities of steel. The equipment comprises three roll stands, four high in tandem, having backing rolls 18 in. in diameter, working rolls, 8½ in. in diameter, all having 14-in. face, and with coilers after the second and third stands. There is also a skin-pass mill two high, having rolls 16 in. diameter with 15-in. barrel.

Particular mention is necessary of the flying micrometer equipment. This instrument employs a combination of mechanical gauging contact and electrical magnification. The contact controls the circuit in such a manner that errors in the material being rolled are revealed in a greatly-magnified and visible form on a micrometer. The chief value of this instrument is its power to gauge material at any point on the width while being rolled. The setting and control are simple and precise, and the gauge readings clear.

In the wire mill a continuous pickling and liming plant is in operation. After passing next through the drying ovens the coils proceed to the drawing machines, 27 in all, 16 single and 11 continuous, which are capable of producing 1,300 tons per week of wire in sizes ranging from ⅝ in. to 0·024 in. diameter. The single spindle blocks can be transformed into two hole or double-deck machines, by means of a lifting die-holder pivoted on the block frame, and so arranged that the incoming rod can take the upper and lower position as desired. The continuous machines take a No. 5 gauge rod, and finish direct to 16- and 17-gauge in one continuous process. These are all air-cooled under pressure, and are provided with a fan, incorporated with the motor, to cool the wire on its own particular block. The coils supplied by the rod mill are of 400-lb. weight, and on some of the finer gauges the length of finished wire measures 800 miles.

Wire required for the nail factory travels by means of overhead cranes to that department which is equipped with 126 machines of the newest type which have an output capacity of 1,000 tons of nails per week. On leaving the machines the nails are carried by a conveyer at ground level to an automatic weighing machine. From there the material is conveyed by elevator to rumbling machines. The nails, after degreasing, are transferred to sloping chutes which take the nails to shaking screens to dispose of nippings and sawdust. Thence they are loaded on to screens which automatically weigh and fill the bags with the requisite quantity. The nail warehouse will accommodate 4,000 tons of nails.

The weekly output capacity of the Cardiff plant is: Steel bars, 3,800 tons; coiled rods, 3,000 tons; hot-rolled hoop and strip, 2,000 tons; cold-rolled hoop and strip, 300 tons; chilled rods, 200 tons; wire, 1,300 tons; and nails, 1,000 tons.

The Whitehead Iron and Steel Co., Ltd.

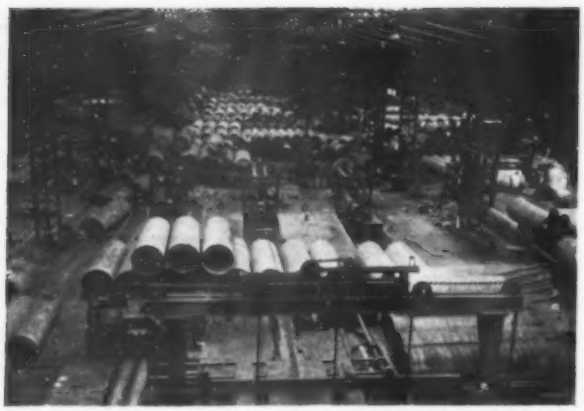
FORMED in 1907 to carry out a scheme, which included the purchase of the leasehold rights of practically the whole of the Tredegar Iron and Steel Works, the Whitehead Iron and Steel Co., Ltd., installed a semi-continuous mill which had been built by the Morgan Construction Company. The new mill, which was installed on the site of the original Bessemer plant, was a new development, and involved a great deal of costly experimental work before its success was assured. The innovation was viewed with much scepticism; while it was acknowledged that greater outputs might be accomplished, doubts were expressed on obtaining the business necessary for its economic operation, and on the degree of accuracy from the mill to meet the requirements of the British trade. In both these respects opinion proved wrong, since the mill proved to be one of the best employed units in the country and its products more accurate than those of the older type mill. This mill embodied the first attempt to make continuous rolling a general utility process, rather than a series of speciality mills, and the remarkable progress made in this direction since those early days shows how correct were the views of this company.

By courtesy of The Whitehead Iron and Steel Co., Ltd.

A general view of the hot mill at the works of The Whitehead Iron and Steel Company Ltd.

In 1914 the company acquired an additional site of 30 acres at Newport, with valuable water and rail transport facilities, but the outbreak of war caused all constructional operations on the new site to be suspended until 1919. Eventually a main building was erected on this site 840 ft. by 88 ft., adjoining which were the main repair shops and general stores, on one side, and the auxiliary bar mill, gas producer house, roll turner's shop and various shops in connection with the cold rolling mills on the other side. The first rolling mill installation in the main building consisted of a combined 12-in. strip and hoop mill. This mill was the outcome of an investigation made in 1919, the design being influenced by that of the 8½-in. Morgan semi-continuous mill in operation at the Tredegar Works of the company, and also by a new type of Morgan continuous hoop mill then in course of erection in Chicago. The mill at Tredegar had then been in operation for twelve years, producing a wide range of bars, special sections, wire rods, hoops and strips. A contract was placed with the Morgan Construction Co. for a continuous mill which combined the main features of the Acme mill and the Morgan continuous skelp mill. This mill was the first of its type and has been in continuous operation since February, 1922, giving entirely satisfactory service.

The billets entering the mill are first delivered on to a billet stage about 7 ft. above ground level, from which they are fed broadside on to feed rolls and carried into the furnace by means of pinch rolls. The furnace is of the Morgan standard incline type, with a suspended arch roof. The furnace chamber is 31 ft. 6 in. wide by 21 ft. from centre of charge to centre of discharge. The billets are discharged from the furnace by means of steam-operated pinch rolls, which engage the pusher-out bar. This carries the heated billet into the first pair of rolls of the roughing mill. The roughing mill consists of a continuous train of seven stands of 12 in. horizontal rolls and one stand of vertical edging rolls, which are placed between Nos. 5 and 6 horizontal roll stands. The finishing mill consists of a train of six stands of 12-in. rolls, which are placed at rather greater centres than the roughing mill train. This latter mill is provided with a duplicate set of roll housings to expedite roll-changing. The strip or hoop leaving the finishing mill at a speed of 1,500 ft. to 3,000 ft. per min., is either reeled in coils or delivered in



By courtesy of Newport and South Wales Tube Co.

General view of lap-welding department, showing welding machines.

straight cut lengths. The mill equipment includes plant for recoiling, splaying and varnishing of hoops.

With the primary object of salvaging any irregularly rolled material from No. 2 continuous strip mill, a cold rolling mill plant, supplied by W. H. Robertson and Co., Ltd., was installed in 1924. To accommodate this plant, the main building was extended by 230 ft., with separate bays for the pickling, slitting, and annealing. The percentage of irregular strip from No. 2 mill was comparatively small, but the cold-rolling department, which has a capacity of 200 tons per week, has become a very valuable adjunct to the hot rolling. The cold-rolling department comprises sixteen 8 in. by 8 in. mills set up in four lines of four rolls, each in tandem. Each mill can, when required, be operated quite conveniently as a single unit.

In the latter part of 1925 the bar mill at Tredegar Works was overwhelmed with orders, and the question of adapting the continuous strip mill to the rolling of bars was considered. As a result it was decided to lay down a new bar mill at Newport, using the existing roughing stands of the continuous strip mill and installing four new stands of rolls.

The bar-mill building, designed on similar lines to that housing the continuous strip mill, is 420 ft. long by 71 ft. wide.

In 1931 a 12-in. by 14-in. semi-continuous mill was installed on a site approximately parallel to that of Nos. 1 and 2 mills. This mill replaced the last of the three-high mills at Tredegar, which, under the stress of modern competition, had become obsolete, and, at the same time, effected important economies in transport costs. The main building housing this mill was 700 ft. long by 96 ft. wide. This, however, has now been extended 175 ft. to provide additional room for dealing with the finished product. This mill, except for the diameter of the rolls and the breaking-up of the drives between independent motors, follows very closely the design of the Tredegar semi-continuous bar mill, which was installed in 1907.

Since then further improvements have been effected. The gradual development in trade conditions led to the removal of the semi-continuous mill from Tredegar to a site at Newport, parallel with the present mills, and the opportunity was taken to introduce certain improvements which brought this unit up to date. More recently a cold-rolling strip mill has been installed, which comprises a four-stand continuous mill, having rolls 7½ in. and 18 in. diameter by 14 in. long; one single straightaway stand, having rolls 8 in. and 20 in. diameter by 18 in. long; and a single straightaway stand having rolls 7½ in. and 18 in. diameter by 14 in. long. The four-stand continuous mill is so arranged that it can be used as a four-stand tandem, or a three-stand tandem and one single stand, and is, therefore, equipped with a reel following the third stand, and a reel following the fourth stand. In addition, each of the single stands is equipped with a reel.

These mills are designed to roll steel strip in widths up to a maximum of 14 in. down to the finest cold-rolled gauges, at a rolling speed from 350 ft. to 700 ft. per min. All are equipped with two motor-operated screwdown gears, and the movement of each screw is indicated on a products meter operated by Selsyn transmitter and receiver. The three and four stands of the tandem mill and both single-stand mills are equipped with flying micrometers on the outgoing side. All stands are equipped with spring-tensioned roll wipers, whilst the first and last of the tandem mills and the two single-stand mills are equipped on the ingoing side with felt-lined strip wipers.

All the mills and most of the auxiliaries at the Newport works of this company are electrically driven. Electric current is taken from the Newport Corporation at 6,000 volts, 3-phase, 50 periods, and converted to voltages desired. Electrical equipment is by the Metropolitan-Vickers Electrical Co., Ltd.

The Newport and South Wales Tube Company Limited.

THE historical associations of this Company date back to 1868, when Sir William Siemens carried out experimental work on the Siemens-Martin open-hearth process of steel manufacture at Landore steelworks. Realising the suitability of this class of steel for tube-making, a company was formed acquiring the British rights of the Mannesmann process, and in the year 1889 seamless steel tubes were put on the market by the Mannesmann Tube Company, from the Landore works. The Newport works were started up in 1918, and seamless tubes are rolled from 6 in. to 16 in. diameter. The Company continued to be known as the British Mannesmann Tube Company, Limited until 1936. The capacity is well over 60,000 tons per annum in seamless quality. The year 1922 saw additional plant put down for the manufacture, by the water-gas roller welding process, of pipes from 14 in. to 72 in. diameter, and the productive capacity of this section is about 20,000 tons per annum.

The electrical supply is taken from the Newport Corporation at 6,000 volts, and is transformed to 3,000 volts, 3-phase, 50 cycles per second, and further stepped down to 400 volts, 3-phase, 50 cycles per second, for auxiliary units generally. There are 315 motors, with a total output of 6,544 h.p. Hydraulic power is provided by four pump units, housed in a separate building, at a pressure of 1,500 lb. per sq. in., and with the aid of intensifiers a pressure of 2 tons per sq. in. is maintained for operating staving presses and test pumps. A pressure of 4 tons per sq. in. is available at the large test pump housed in No. 10 bay. The motors on the pump units are of 250 h.p., operating on the 3,000-volt a.c. supply. Air pressure is available at 100 lb. per sq. in., provided by three air compressors, driven by 3,000-volt a.c. motors.

The tube mills are under a roof of four bays, each 234 ft. long and 78 ft. span, and in this section are two reheating furnaces capable of an output of about 475 tons per

The pilger mills at the Newport and South Wales Company's Works.

24 hours. Both furnaces are fired with pulverised fuel at a temperature of about 1,400° C., and the ingots from these furnaces are fed to a rotary type piercer. The piercing mill is driven by a 2,500 h.p. tandem-compound steam engine, transmitting power by cotton ropes through a wheel 18 ft. 6 in. in diameter to a second motion shaft carrying a wheel 21 ft. in diameter. The product of the piercer is in the form of a hot hollow bloom, and is conveyed to one of two " pilger " mills by an electrically operated bogie. The two pilger mills are of the Mannesmann type, operated by a 2,500-h.p. steam engine, which is a duplicate of the one driving the piercer, the engine being situated between the two mills.

As the rolled tubes leave the pilger mills, the pilger heads are cut off with 72 in. diameter electrically driven hot saws ; by live roller gear the tubes pass along to hydraulically operated arms which send them over skids to the sizing mill inlet train. The sizing mill is driven by a 250-h.p., 460-volt a.c. motor. Passing through the sizing mill the tubes are conveyed by live roller gear on to the weighing machine, are weighed and then distributed to the cutting and finishing departments.

Extensive finishing departments are necessary and occupy three bays, each 78 ft. span and 1,045 ft. long, with two additional bays 660 ft. and 550 ft. long. This gives ample space for the manipulation and inspection of material. Tubular equipment for oilfields is made in accordance with the specifications of the American Petroleum Institute, and a special room is set aside for the storage of various master gauges, with which all working gauges are checked at frequent intervals. This room is maintained at a constant temperature, and before any threading tool or chaser is issued to the operator it is checked by projecting the outline on to a screen showing the profile of the thread magnified 50 times.

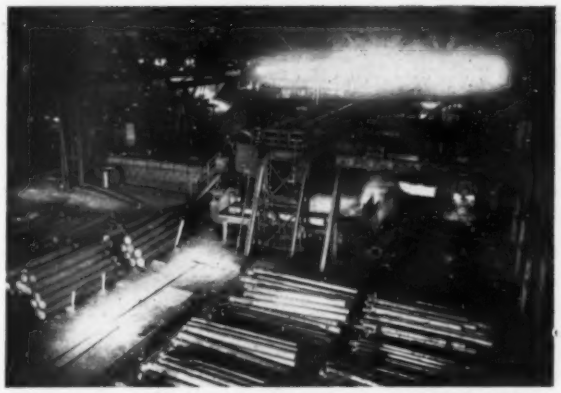
For the water-gas hydraulic roller welding department there are three gas producers capable of a combined production of 1,000,000 cub. ft. of gas per 24 hours. There are five welding machines in this section, which comprises two bays, each 660 ft. long and 78 ft. span, together with a gas-fired plate furnace, plate-bending machines, and auxiliaries such as socket-forming machines, staving presses and test pumps, and bitumen protection plant. The latter is for the inside coating and/or lining of water mains and the wrapping and/or sheathing of the outside.

The pipes for lining are de-scaled internally by shot-blasting, then pre-heated and dipped into a bath of molten bitumen to form a primer, after which the pipe is immediately transferred to a spinning machine. An added supply of molten bitumen is then fed in, to give a pre-determined thickness, and the pipe then revolved until the bitumen, by centrifugal action, has formed a complete lining and protection to the pipe. It is then placed between headstocks and again revolved for the purpose of feeding on to the outside a wrapping and/or sheathing, the latter consisting of bitumen with an added filler of silicious material.

The warehouse, or despatch department, is situated at the extreme end of the building, to which all material flows during manufacture. All bays are equipped with electrically operated overhead cranes, of which there are 21 in the works. There is a large engineering shop in which maintenance is carried out. The laboratories are well equipped and include apparatus for determining the limit of proportionality, rate of creep, etc., at elevated temperatures.

The East Moors Works of Guest, Keen, Baldwins Iron and Steel Co., Ltd.

ORIGINALLY built in 1889-1893 by the Dowlais Iron Co., Ltd., the East Moors Works at Cardiff consisted of blast furnaces, open hearth shop and a plate mill. On the amalgamation of Guest, Keen & Nettlefolds, Ltd., and Baldwins, Ltd. in 1930, to form the British



General view of the mills at the works of Newport and South Wales Company Ltd.

(Guest, Keen Baldwins) Iron & Steel Co., Ltd., the works at Port Talbot, Cardiff and Dowlais were formed into one concern. For economical reasons steel manufacture was concentrated at the Port Talbot and Margam Works and in 1931 steelmaking at Cardiff ceased, but the blast furnace plant was kept working.

In 1934, Guest Keen Baldwins decided to erect a complete iron and steel plant on the site at Cardiff with a view to a capacity of 500,000 tons of pig iron and 350,000 tons of steel, and by 1936 the initial part of the new works was put into production. Of the old plant the blast furnace and sinter plant with blower house and repair shops remained. The scheme then put into execution included a coal washery and coke oven plant, an ore-handling plant, the rebuilding of two of the three blast furnaces and other reconstruction of the blast furnace plant, a new gas-cleaning plant with gasholders, open-hearth plant, rolling mills and all accessory plant.

The coal handling and washery plants were designed to handle coal at the rate of 170 per hour. The coke oven plant was put down for the production of approximately 6,000 tons of blast-furnace coke with 18 hours coking time per oven charge and the handling of all by-products. Two coke oven batteries were built, each of 29 ovens. These are of the Becker cross regenerative combination type, each oven being 43 ft. ½ in. long, face to face of oven brickwork, with a mean width of 18 in. and a height of 12 ft. 6 in. Eleven additional coke ovens, similar to those already installed have since been put into commission. These ovens are of the compound type and may be heated either by part of the high calorific value coke-oven gas produced or by the blast furnace gas. When the ovens are heated by coke oven gas all the regenerators are used for the preheating of air and the absorption of heat from the waste gases. When blast-furnace gas is used, the gas is preheated as well as the air.

The by-product plant is of the semi-direct type, designed to handle the crude gas produced from the coal carbonised at the ovens and to remove from it tar, ammonia and benzole before passing forward to the 1,000,000-cu.ft. capacity Klonne gasholder. The by-product plant comprises a cooling installation to reduce the temperature of the hot gases leaving the ovens, and exhausting plant for drawing the gases from the ovens and delivering them through the by-product plant, an electro-static detarring plant, a gas reheater, saturaters for recovery of ammonia in the form of ammonium sulphate, final gas coolers for cooling down the gases and extraction of naphthalene, and finally, a series of benzole scrubbers for absorbing benzole vapours from the gas by means of wash oil. Associated with the various units are all the necessary pumps, drains and seal pots, plant for extraction of benzole from the wash oil, benzole rectification plant, storage tank farm, etc.

The blast furnace plant now comprises four blast furnaces, each with an average output of 3,000 to 3,500

tons per week and provision is made for handling raw materials and disposing of the output of a plant which is producing about 1,300 tons of pig iron per week. There are ten hot-blast stoves, each 95 ft. high and 24 ft. diameter, fitted with the Hotspur system of chequering and with Steinhart automatic combustion-control burners. All the pyrometers and other instruments for the four furnaces are in a central instrument house and are so arranged that they can be seen through the windows without the necessity of going inside. All the furnaces have the usual series of pyrometers and pressure gauges. Two items of interest are automatic stockline controllers and recording pyrometers showing the temperature of the blast furnace stack at various places.

The melting shop is designed as an integral part of a balanced iron and steel works, in which the only fuel to be used for steel production should be the by-product gases from the coke ovens and blast furnaces. The plant operates on a mixture of blast-furnace and coke-oven gas of about 220 B.th.u./c.ft., but five modern Morgan gas machines are installed as an emergency gas plant. There are four tilting furnaces, one of 250 tons capacity recently installed and three of 200 tons capacity, a 600-ton active mixer and two fixed furnaces.

The tilting furnaces are essentially of the same design as the mixer, having intermediate interchangeable ports, air-spaced and insulated regenerators, electrically-operated tilting, the same design of control and reversing valves, and are fitted with the same instruments and pyrometers, etc. Hot metal from the blast furnace is brought to the mixer in 120-ton mixer cars, which discharge the iron into transfer ladles of 45 tons capacity ; these are lifted through a hatch in the floor and the iron discharged into the mixer through the usual hot-metal chutes. Iron from the mixer is discharged on the casting side into a ladle on a transfer car, which passes under the mixer and is lifted through another hatch for charging into the steel furnaces.

Teeming is done from the cranes at four teeming stages, and at one fixed stage with hydraulic pusher for the ingot car. After pouring the ingot, mould cars are transported to the stripper house, which is situated between the steel plant and the mills. After stripping, the ingots continue on their way to the mills on the mould cars. Here the ingots are lifted by overhead ingot cranes and placed in the soaking pits.

The ingot-heating plant consists of seven high-efficiency twin-pit soaking-pit furnaces. Each pit accommodates ten 3–4-ton ingots. The total ingot holding capacity is therefore 140 ingots. These soaking pits are fired with blast-furnace gas. The heated ingots are transferred to the mill by an electric-ingot bogie, distantly controlled, running the full length of the furnaces.

The rolling mills consist of a 40-in. blooming mill, a Morgan continuous sheet, bar and billet mill, and a 21-in., three-stand, three-high, light section mill, with complete auxiliary plant and equipment, all electrically driven.

The blooming mill has rolls 40 in. diameter by 8 ft. long, with 43½-in. diameter pinions with a 5-ft. 11-in. face, capable of rolling 3-ton ingots down to 5-in. blooms at the rate of 90–100 tons per hour. The mill is driven by an 18,800 peak horsepower reversing electric motor, which is coupled to the pinion housing through a Bibby flexible coupling. The motor has a cut-out torque of 230 metre-tons at 60 r.p.m. and can reverse the mill from 56 r.p.m. in one direction to 56 r.p.m. in the other direction in 2 secs. The mill motor is driven by an Ilgner set with a 5,000 b.h.p. 3,300-volt A.C. motor, which is situated in the main works substation immediately adjacent to the mill motor house. The roll screw-down gear is driven through two 75/150 h.p. motors, taking current from a Ward Leonard set installed in the works substation. The mill is fitted with electrically driven mechanical-manipulator guides on both sides, which are fitted with electrically-operated turning-over steel fingers of special design on the two front guides. The manipulator is of the Freimel type, which enables small blooms to be turned over with ease. Each pair of manipulator guides is driven by a 75-h.p. electric motor, and the manipulator fingers on each guide in front of the mill by one 30-h.p. motor on each guide, driving through worm-gear boxes and connecting rods. The mill scale is collected in cars running on rails in tunnels in the mill foundations, the cars being lifted up and emptied into trucks by the overhead crane. In front and behind the mill rolls a patent breast roll is fitted. The mill-working tables are fitted with forged-steel rollers ; all other rollers on the runout racks are in cast iron. All rollers run in white metal oil-pressure ring-lubricated bearings, the line shafts and bevel gears being totally enclosed in oil-tight lubricating troughs. The pinions and pinion bearings are lubricated by oil supplied under pressure by separate oil pumps located in the mill motor house. The mill roll, neck chocks, screw-down gear and manipulators are all lubricated by multified grease pumps, those on the mill being separately driven, while the pumps on the manipulators are driven from the manipulator driving gear.

The Morgan continuous sheet-bar and billet mill consists of six horizontal stands of rolls with two vertical edging stands. This mill is capable of rolling billets down to 2 in. × 2 in. sections and sheet bars down to ¼ in. thickness and up to 16 in. maximum width. The main mill motor has a full load output of 4,000 h.p., and is of the slow speed synchronous type direct coupled to the mill gear box, and housed in a separate motor and switch house in the mill bay. The edging mills are each driven by 125-h.p. motors running at 400/800 r.p.m. Blooms are cut or cropped when required before entering the mill in a shear of the pendulum type designed to cut the bloom when in motion.

The 21-in. light section mill is of the three-stand, three-high type, with motor-driven tilting tables in front of and behind each stand. The two roughing stands are coupled together and driven from a pinion housing with pinions 21 in. diameter by 26 in. face, which, in turn, is driven by an electric motor of 1,500 b.h.p. through a single reduction gear having flywheels on the high-speed shaft, and capable of dealing with peak loads of 11,800 h.p. The control gear is arranged to give any mill-rolling speed between 130 r.p.m. amd 60 r.p.m. The flywheels have a total stored energy at maximum speed of 35,000 h.p. secs. The finishing stand is driven from its own pinion housing by a variable speed-motor of 1,200 h.p. driving through a single reduction gear without any flywheels.

The Company is justified in claiming that the East Moors Works is one of the most modern self-contained iron and steel works in this country. The products of the plant consist of by-products from the coke-oven plant, pig iron (basic and hæmatite), billets, sheet bars, and small sections of various kinds. Outstanding features of the plant are its simple and clean layout and the absence of smoke—all heating being obtained by means of blast-furnace and coke-oven gas.

Sir Malcolm Campbell's Bluebird

Although the whole of the hull itself is built of wood, Duralumin has been used to sheath the bottom of the stabilisers, and light-alloy trusses are employed for internal bracing. The superstructure of the engine and fore-deck is made of Birmabright for lightness and is in four sections.

Export of Aircraft and Aero Engines

The Board of Trade has issued an order superseding that recently made with regard to the export of aircraft and aero engines. Open General Order G.L.168 has been superseded. Until further notice, no aircraft engines and no aircraft registered in the United Kingdom—except aircraft which are covered by special dispensations from the Air Ministry, and aircraft clearing from approved Customs aerodromes either on air line services or specially authorised flights—shall be shipped or flown from the U.K. to any overseas destination without a special export licence granted by the Board of Trade.

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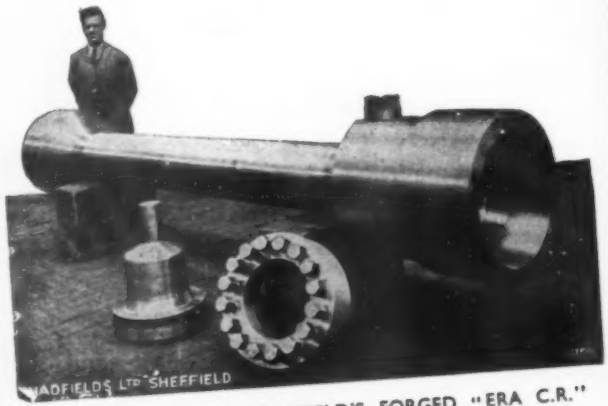
GROUP OF CASTINGS MADE IN HADFIELDS "ERA H.R.I.S." HEAT-RESISTING STEEL USED IN PLANT FOR THE PRODUCTION OF TIN BY THE SIAMESE TIN MINES LTD.



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The Iron and Steel Institute

The salient features and results of research given in the scientific and technical papers, which were to have been presented at the Autumn Meeting of the above Institute, are summarised.

THE cancellation of the Autumn Meeting of the Iron and Steel Institute, which was to have been held at Cardiff on September 12–15, was not unexpected in view of the changed conditions resulting from Britain being at war. Obviously, normal peacetime pursuits must give way to the more urgent requirements of the nation, but considerable disappointment has been felt in South Wales because the Institute is strongly represented in this area and members have been applying themselves for some time to a programme which would ensure for the visiting members and their ladies a very enjoyable and profitable time. South Wales is one of the oldest areas in Britain concerned with the production of iron and steel and in recent years so much progress has been made in the development of schemes for increased and improved production that representative firms were anxious to show members from other areas the contribution South Wales is making to the progress of the iron and steel industry in Britain as a whole.

Althcugh circumstances have prevented the holding of this Meeting and have disappointed many who were keenly looking forward to the opportunities for visiting works, where arrangements had been made for receiving visitors, the brief descriptions of these works, given elsewhere in this issue, will assist readers to visualise some of the developments in this area. Apart from the business of the Institute conducted at the Autumn Meeting, one of its primary purposes is the opportunity it affords for the presentation of Reports and scientific and technical papers. In addition to a range of papers of a scientific and technical character covering many fields, which were on the programme, for presentation and discussion at this Meeting the Ninth Report on the Heterogeneity of Steel Ingots was to have been presented. The Report is published and is reviewed elsewhere in this issue ; the technical papers are printed and will be published in the Journal of the Iron and Steel Institute, but the salient features and results of the several pages are briefly summarised in the following notes :—

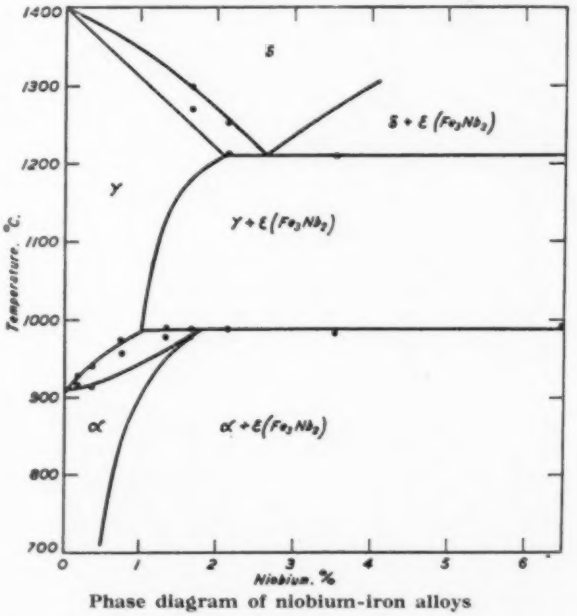
An X-ray Investigation on the Iron-rich Nickel-Iron Alloys

IN spite of investigation during many years the iron-nickel system is still very imperfectly understood. The results of thermal microscopical and magnetic work cannot yet be explained in accordance with the phase rule. Two entirely different types of diagram have been suggested, one postulating the existence of a eutectoid, the other requiring only two single-phase fields. X-ray investigations have discredited the eutectoid hypothesis by showing that the so-called γ-γ^1 transformation in the nickel-rich alloys is merely the magnetic change point, and cannot have anything to do with a eutectoid. The second type of diagram seemed to fit the facts better, since there are only two types of atomic arrangement—body-centred cubic (α) and face-centred cubic (γ). Attempts to delineate the phase boundaries on this basis have proved unsatisfactory. The investigations reported in this paper by Dr. A. J. Bradley and Mr. H. J. Goldschmidt have been carried out in the hope of providing an alternative explanation of the X-ray results.

X-ray powder photographs of iron-nickel alloys have been taken after long times of heat-treatment. They give unexpected results which cannot be explained on the basis of current views. In spite of the fact that there are only two types of structure (body-centred cubic and face-centred cubic), the system is quite complicated. Reactions take place at two definite temperatures, 580° and 350° C. Below 580° C. there is a sudden broadening of the two-phase gap, which is quite narrow above this temperature. From 580° down to 350° C. $\alpha + \gamma$ two-phase structures are formed at all compositions between about 6–8% nickel (α) and 23–26 atomic-% nickel (γ). At about 350° C. the α and γ phases react to form α_1 with the approximate composition Fe_3Ni, which is a low-temperature body-centred cubic phase. It is impossible to get direct evidence for the two-phase region $\alpha + \alpha_1$, because the lattice spacings are almost identical. The $\alpha_1 + \gamma$ region stretches from about 25 to 40 atomic-% nickel at 325° C. Invar, the composition of which places in this region, must be regarded as a supersaturated γ solid solution which may, under certain conditions of heat-treatment, precipitate Fe_3Ni.

Niobium-Iron Alloys

THE investigation reported in this paper by Dr. R. Genders and Mr. R. Harrison comprises a study of the constitution of the niobium-iron system with particular reference to the phase changes occurring in the alloys of low niobium content. The phase diagram of the system is of the same type as that of tantalum-iron alloys. The authors conclude that the niobium-iron alloys containing up to 50% of niobium may be considered as an alloy system of iron and the compound Fe_3Nb_2. A eutectic of the solid solutions δ and Fe_3Nb_2 (ϵ) is formed at a composition of about 18% niobium. The solubility of Fe_3Nb_2 in α-iron is small at room temperatures, below 0·36%, and increases to a content of about 1·8% at the peritectoid temperature of 989° C. The solubility in γ-iron also increases with temperature from about 1·0% at 989° C. up to about 2% at the eutectoid temperature of 1,220° C.



Phase diagram of niobium-iron alloys

The addition of niobium to iron raises the hardness progressively. Solution of ϵ by heating and quenching produces a small increase in hardness, and alloys containing more than 1% of niobium are further hardened by tempering at 700° C. after quenching. A phase diagram deduced from the thermal, microscopical and hardness characteristics of the alloys containing up to 6% of niobium is given and is reproduced here. This diagram completes in detail that put forward by Eggers and Peter. Though in broad agreement with the work of those authors, the present

data provide grounds for making some corrections in detail, as well as for filling in the portions which were previously only tentative.

The pure niobium-iron alloys have no present industrial significance. Niobium, however, is finding a growing field of use as a minor constituent of steels, and the information now available regarding the constitution of the binary alloys is a necessary basis for the further study of more complex materials, particularly those, such as nitriding steels, in which niobium is necessarily in excess of that required to absorb the carbon present.

The Cause of Roll-marks on Tinplate

ROLL mark or roll-pick-up is a defect in tinplate manufacture which may in certain works result in a wastage of sheets amounting to 15% or more of the total output. The appearance of this defect in the finished tinplate is that of a band of parallel elongated depressions, each about $\frac{1}{8}$ in. or more long and $\frac{1}{32}$ in. deep, and extending, in many cases, along the whole length of the sheet. The depressions are rough and irregular in outline, and do not "take" the tin coating readily, and are therefore sources of corrosion when the sheet is fabricated. Apart from this, the appearance of the sheet is ruined.

This investigation by Mr. Roosevelt Griffiths revealed the fact that the defect of roll-marks did not manifest itself until some hours after the rolls had been in commission. This would occur on Monday evening if the rolling operations started with hot rolls on Monday morning. The trouble continued throughout Monday night and Tuesday, and eventually ceased on Tuesday night or Wednesday morning. For the remainder of the week conditions were normal. If, due to roll breakage, it was necessary to change a roll during the week, similar conditions prevailed, and the roll marks appeared on the sheets after an interval of time, to disappear subsequently after a day or so. The type of steel rolled had a marked effect in that "basic" steel was more prone to develop the defect than "acid" steel.

Careful examination of the sheets rolled throughout the week revealed that, corresponding to the periods when roll-marks were prevalent, some of the sheets exhibited a rough appearance. Raised streaks of scale-covered metal were visible, which appeared to be attached to the underlying metal of the sheet. The dimensions of these streaks varied somewhat, but were approximately $\frac{1}{8}$ in. or more long, and up to $\frac{1}{16}$ in. wide. At one end of many of the streaks was a slight depression.

It is the practice, when roll-marks become prevalent, to rub the surface of the roll with a grinding stone, which is pressed against the roll-surface with the aid of a long handle, levered against a support. This is done in order to remove small projections which are attached to the surface of the rolls and which are continuously forming as the rolling operations proceed. These projections, if allowed to remain on the roll, would, of course, produce indentations or roll-marks on the sheets which subsequently pass between the rolls. It seemed reasonable to assume that the streaks formed the material from which the projections on the rolls were made.

In order to find an explanation of the formation of these streaks, it was necessary to study carefully the rolling operation. As stated previously, only the bottom roll is driven, and the top roll is therefore driven through the medium of the material between the two rolls. It was necessary, therefore, to have some information concerning the relative speeds of the top and bottom rolls under various conditions of working and idling.

The author discusses various contributing factors, such as method of working, roll camber, and relative speed of rolls, and concludes that the ultimate cause of the defect is due to particles of material picked up by the rolls from the sheets as a result of accelerated slip occurring locally between a roll and a sheet; the pressure and velocity of this slip is sufficient to cause the particles of the sheet to become heated and "tacky." The evidence in support of this contention being the recrystallised character of the streaks or particles on the sheets.

In considering the possible ways of alleviating the trouble, it would seem that if the top rolls were driven the trouble would disappear. A somewhat more complicated drive is then necessary, but there are indications that this method is being adopted. A closer texture of the rolls is another step which might mitigate the trouble. This would involve the use of alloy additions, such as nickel, to refine the structure. It is essential that care be taken to ensure that the amount of deformation in the finishing rolls is uniform over the greater part of the width of the pack by paying close attention to the form of deformation taking place in the roughing as well as in the finishing rolls.

Antimony in Mild Steel

THIS paper by Dr. B. Jones and Mr. J. D. D. Morgan deals with the influence of varying amounts of antimony on some of the properties of a 0·17% carbon steel. Twelve steels of basic electric origin and four high-frequency steels were tested with varying antimony contents up to 19%. Like arsenic and phosphorus, other elements in group VB of the Periodic Table, antimony embrittles steel when present in sufficient quantity, being dissolved in α-iron and stabilising it. It is shown that steels with 0·17% of carbon and up to 0·69% of antimony can be hot-forged and rolled. Higher rolling temperatures are necessary above 0·55% of antimony. Red-shortness occurs in steels containing more than 0·69% of antimony, and a 1·45% antimony steel cannot be hot-worked without disintegration. Antimony has an inappreciable strengthening effect on the tensile properties of steel, 0·69% raising the maximum stress value by only 2 tons per sq. in., while the ductility and impact values are decreased. Higher antimony steels have little tensile strength and are seriously embrittled.

The A_1 point is practically unaffected by antimony, but the A_3 temperature is progressively raised. With 2·8% of antimony the Ac_3 is raised from 860° to 940° C. High-antimony steels are practically non-hardenable, owing to a stabilised ferrite structure. Antimony contents up to 0·24% do not adversely affect carburising or case-hardening properties, but larger amounts cause abnormal structures, and a consequent soft case on quenching. The response of the steels to nitrogen-hardening is negligible. Cementation of steel with antimony powder is readily effected and the cemented steel is highly resistant to atmospheric corrosion and to acid attack. Steels with a low antimony content are more susceptible to atmospheric and acid corrosion than carbon steel. With increasing antimony, however, the steels become more resistant. Above 0·55% of antimony they are increasingly resistant to attack by 5% and 25% sulphuric acid at 25° C. They resist attack by hydrochloric acid to a less degree.

The Influence of the Steel-base composition on the Rate of Formation of Hydrogen-swells in Canned Fruit Tinplate Containers—Part 1

AN outstanding problem associated with the storage of fruit in a tinplate container has so far not been entirely overcome: the formation of so-called hydrogen-swells during storage. These "blown" or "domed" cans are caused by the evolution within the can of hydrogen formed by the corrosion of the tinplate by the fruit acids, and are unmarketable. Although a great deal of canned fruit is so readily consumed that the problem does not arise, there are at least two important directions in which a reduction in the rate of hydrogen swells would be very desirable: (1) In assisting canners to "carry over" packs—that is, a number of cans filled with the same fruit—from one fruit season to the next, when there is a glut, or to ensure against a poor harvest in the next year; (2) in facilitating the export to hot climates of fruits that at present fail too rapidly to be a commercial proposition,

owing to the increase of the corrosion rate with increase of temperature.

Previous researches have indicated that one important factor influencing the rate of tinplate corrosion and hydrogen formation is the composition of the steel base. The investigation described in the present report by Dr. T. P. Hoar, Mr. T. N. Morris, and Mr. W. B. Adam, deals with the influence of sulphur, phosphorus and copper contents of the steel base on the rate of hydrogen-swells in a representative selection of British fruits. The method of approach was by taking a " random sample " and using the results as a means of calculating the results for the large population from which the sample was drawn. This method was adopted because it is desirable from every point of view to discover the most favourable steel composition that is produced in present practice before embarking on a search for material even better.

In this paper, results for blackcurrants, sweet white cherries, gooseberries, loganberries, yellow Pershore plums, raspberries and strawberries in double-lacquered cans are given ; further results will be reported later. As well as the correlation of the rate of formation of hydrogen-swells with the steel-base composition, correlations have been made with the corrosion rate of the steel base in citric acid under laboratory conditions, and the electrochemical relationships previously described* have been further clarified.

The steel base of the (pack-rolled) tinplate at present on the British market has the following average composition : Sulphur, 0·03–0·09%, mean, 0·06% ; phosphorus, 0·02–0·09%, mean, 0·055% ; copper, 0·03–0·22%, mean, 0·10% ; and all the following results from this investigation refer to this type of steel base only.

(1) For the finished sheets of this material, high sulphur content is associated with high phosphorus content, and high phosphorus content with low copper content ; but for a fixed phosphorus content, the higher-sulphur steels tend also to be higher in copper. Tentative suggestions for the causes of these associations are made.

(2) A more rapid formation of hydrogen-swells in cans of fruit was significantly associated with a higher rate of corrosion of the steel base in citric-acid solution for experimental packs of black currants, sweet white cherries, gooseberries, loganberries, yellow Pershore plums and raspberries in double-lacquered cans ; the agreement was by no means exact, but was a general tendency.

(3) For the packs of blackcurrants, gooseberries, loganberries, Pershore plums, raspberries and strawberries in double-lacquered cans here studied, the rate of formation of hydrogen-swells was significantly less for cans made from steel bases higher in copper, and therefore lower in phosphorus ; for the packs of blackcurrants, gooseberries, loganberries and raspberries, the factor producing the better result was very probably the higher copper, while for those of Pershore plums and strawberries it was very probably the lower phosphorus. For a similar pack of sweet white cherries, the copper and phosphorus contents were immaterial. For all the packs, the sulphur content was immaterial.

(4) Since fruits are themselves variable, it is not possible to *predict with certainty* that the results given in (3) will apply to *any* packs of these fruits ; but since high-copper, low-phosphorus tinplate has been shown to be favourable in six out of seven packs of seven typical fruits, its general use *may be expected to be advantageous on the average of these fruits.*

(5) The *amount* of improvement to be expected from the use of high-copper (about 0·16–0·22%), low-phosphorus (about 0·03–0·045%) steel rather than unspecified material taken at random, is estimated, roughly but conservatively, at a doubling of the time during which the first 10% of any given pack may be expected to fail through hydrogen-swells, for those fruits for which steel-base composition appears to be significant (see (3)).

(6) The " artificial " corrosion rate of steel base in 2 and 0·5% citric-acid solutions, under conditions of free and of restricted access of air, respectively, is significantly less in the higher-copper, lower-phosphorus steels. Both factors may be operative. There is, however, no further fall in corrosion rate above 0·2% of copper, but indeed some evidence of a slight rise.

(7) On the evidence of this and previous work, it appears that about 0·2% of copper is the optimum value, from the fruit-acid corrosion and hydrogen-swell point of view ; the phosphorus content should be as low as pack-rolling considerations allow. As before, this applies (so far) only to the six fruits that give the significant results of (3).

(8) Correlation of corrosion rate in citric acid with corrosion potential in the same acid confirms the previous conclusion that different steels of the type under study have *approximately* similar cathodes, the differences being largely anodic ; but the smaller cathodic differences are sometimes of importance. Cathodic efficiency for the reaction $2H^+ + 2\epsilon \longrightarrow H_2$ in citric acid appears to be inhibited by increase of sulphur and stimulated by increase of phosphorus content ; preliminary observations indicate also that cementite may be a stimulator of importance. For any steel, the height in millivolts of the corrosion-potential/corrosion-rate point above the average logarithmic curve given by all these points is an indication of the cathodic efficiency, and is termed the " cathodic increment."

(9) For the packs of white cherries and gooseberries in double-lacquered cans here studied, the rate of formation of hydrogen-swells was significantly greater for cans made from steel bases showing higher cathodic increments ; thus it is probable that such steel base is, in general, undesirable for such packs.

* T. P. Hoar and D. Havenhand, " Factors Influencing the Rate of Attack of Mild Steels by Typical Weak Acid Media," *Journal of the Iron and Steel Institute*, 1936, No. I, p. 239P.

Transformation of Austenite on Cooling Morphology and Genesis of the Aggregates Formed

IN this paper by Mr. H. Jollivet an attempt is made to draw up a classification of the structures which form in low-alloy steels during the isothermal decomposition of the austenite in the upper ranges (Ar') and the intermediate ranges (Ar''). In addition to pearlite and troostite, the granular structures are described which have their origin in the lower portion of the upper range (Ar'), and for which there is no special designation. On the other hand, the author adopts the term " bainite," which has already been suggested, to denominate the structures which appear in the Ar'' region, in preference to the terms acicular troostite, troosto-sorbite, troosto-martensite, etc.

The investigation of a certain number of alloy steels which contain small percentages of nickel, chromium and molybdenum shows that all the structures obtained by isothermal transformation of austenite exhibit the same features, and may be reduced to a few types. They are simply dependent upon the conditions existing at the time of formation. It is sometimes rather difficult to identify the characteristics of the structures obtained after total transformation. The structures, as formed, are usually unstable, and may be modified by secondary phenomena, such as coalescence and graphitisation. The formation of certain types of pearlite or bainite—at the highest temperatures—is so slow that coalescence takes place during the process of formation. This then results in aggregates in which the cementite is coalesced in zones of ferrite without any definite form.

For each composition, the structures observed, governed by the rate of nucleation (N_g) and the rate of crystallisation (N_c), are characteristics of the temperature of formation. The partial transformation of austenite leads to the formation of as many structures as there are temperatures at which the steels may have been held. When the change from one temperature to the next is abrupt, the change of structure is also discontinuous and not gradual. The zones already transformed act as centres of transformation

for the new structure and at the same time fresh centres appear.

There are many difficulties associated with the nomenclature of these structures, which is based on arbitrary divisions, the variations of structure in each range being of a continuous character. Except for certain very definite types, the features are difficult to analyse. If the structures are formed of ferrite-cementite aggregates, they are differentiated by the distribution of the constituents, or by the mode of growth of the transformed regions. The analogies and specific characteristics of the structures in each of the regions are outlined, and an interpretation is given which suggests that the formation of the initial nuclei is due to two different constituents—viz., cementite for Ar′, and supersaturated ferrite for Ar″.

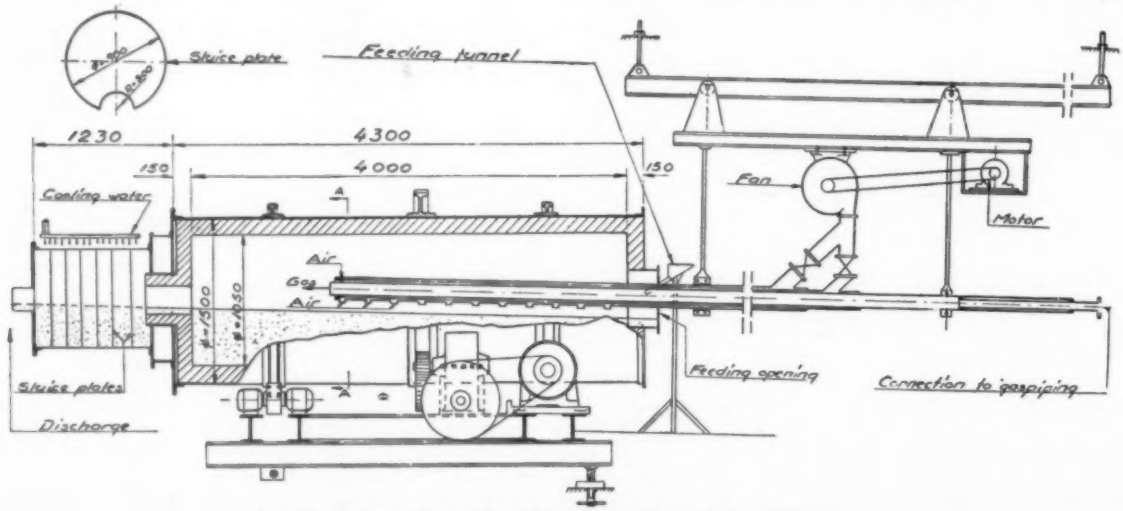
Decarburisation of Granulated Pig Iron
The " R.K." Process

THIS paper by Professor Count Bo Kalling and Mr. Ivar Rennerfelt deals with a new method, known as the " R.K." process, for converting pig iron into a product with a low carbon content. The iron tapped from the blast-furnace is granulated in the molten condition, and the granulated iron is subsequently fed continuously into a rotary furnace, where it is decarburised without melting in a gas mixture containing carbon dioxide and carbon monoxide in such proportions that decarburisation takes place practically without the simultaneous oxidation of iron or other metallic constituents. Decarburisation of granulated iron over a period of 14 days gave an average content of not more than 0·03%. But the authors state that it is not necessary to force down the carbon content of the granulated iron to this figure in order to obtain 0·03% carbon in the steel made in the following steel-melting process. When producing material with low carbon content, the grains, in the normal course of the process, carry a variable amount of oxide on their surfaces, and when the material is again heated in the melting furnace, the oxide present causes some further carbon to be removed before fusion occurs. Melting tests have shown, for instance, that the carbon content can be reduced from about 0·10% and probably more in the grains to between 0·02 and 0·03% in the molten bath.

authors, who are the inventors, discuss the theory of the process and give the results of experiments in the laboratory and on a small technical scale, and also from the first furnace operating on a full industrial scale. A longitudinal section of the Fagersta decarburisation furnace is reproduced in the accompanying illustration.

The decarburised granulated iron produced is primarily intended as a substitute for steel scrap for remelting in steel furnaces, particularly to fill the need for a low-carbon material of known and constant composition and of known origin as a raw material for the manufacture of high-quality steel. It seems to become more and more difficult to obtain scrap that is sufficiently free from the usual alloy constituents, such as chromium, nickel and copper, besides other unknown impurities which may influence the quality. The product will have a field of use particularly in such processes where no appreciable decarburisation usually takes place, such as the electric and crucible steelmaking processes. For the acid processes it is, of course, necessary that the granulated product be made from a pig iron sufficiently low in sulphur and phosphorus. For the basic processes it will also be possible to use granulated iron made from ordinary pig iron for the production of a material with specific requirements.

The possibility of reducing the carbon content of the granulated iron to particularly low values before and during melting seems to open a not unimportant field of application in the production of alloy steels with low carbon contents. The authors suppose that it is too early to answer definitely the question whether the " R.K." process may also become of importance as a decarburising method for the manufacture of ordinary qualities of steel in competition with other methods. It does not, however, seem quite impossible. The yield is higher than that of the Bessemer process and the conversion costs for a large output would be low. The disadvantage of the method—namely, that the material is not obtained in the molten state, is to some extent counteracted by the fact that no apparatus corresponding to the mixer is required to keep the iron hot. In comparison with, say, a duplex process in which the Bessemer converter is used for a preliminary treatment, it is therefore not impossible that the " R.K." process will under certain conditions prove advantageous.



Longitudinal section of the Fagersta decarburisation furnace.

The composition of the gas mixture in the furnace is regulated by burning the reaction gas, leaving the charge together with some blast-furnace gas with air, which is blown in a special way towards the inclined surface of the revolving charge. The consumption of blast-furnace gas is very low on account of the exothermal character of the process, and, in continuous operation, practically no addition of fuel will be necessary if the residual carbon content of the product is not to be especially low. The higher nitrogen content in the steel produced by the Bessemer process should be kept in mind in this connection.

In cases where the pig iron cannot be directly converted into steel, for instance, if the blast-furnace is situated at a long distance from the steel plant, and any hot-metal process cannot, consequently, be considered, the advantages of the " R.K." process become more distinct. In the case of new plants, the simplicity of the method and the low costs of building are especially advantageous.

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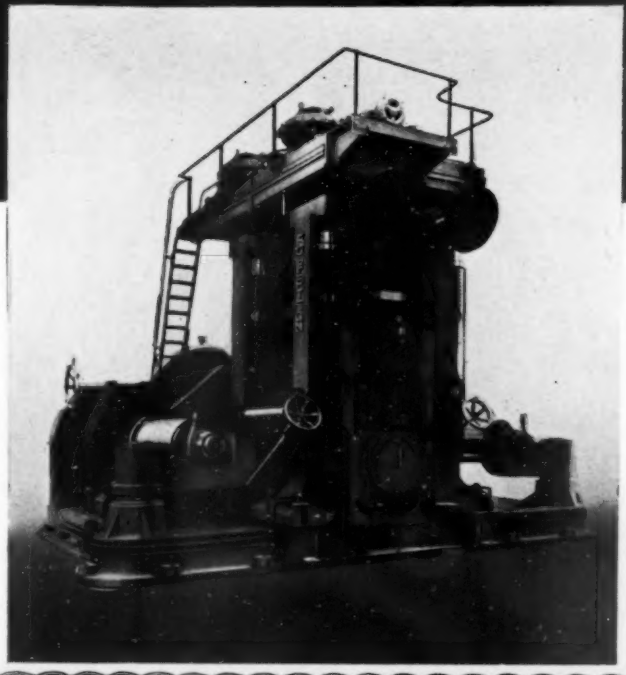

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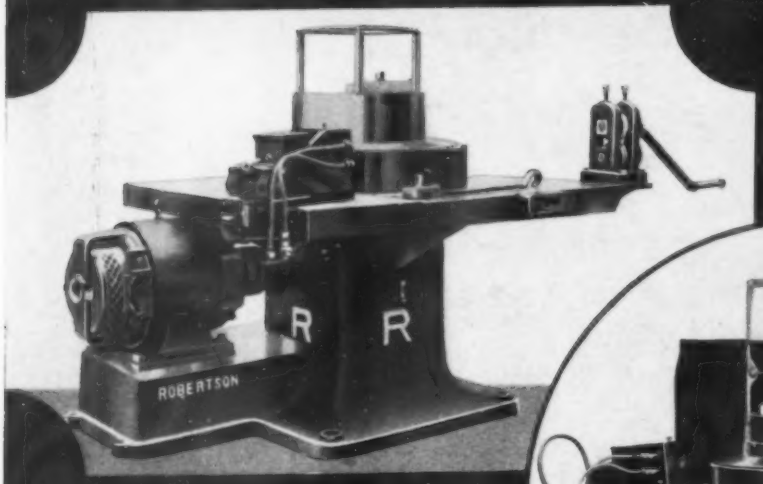

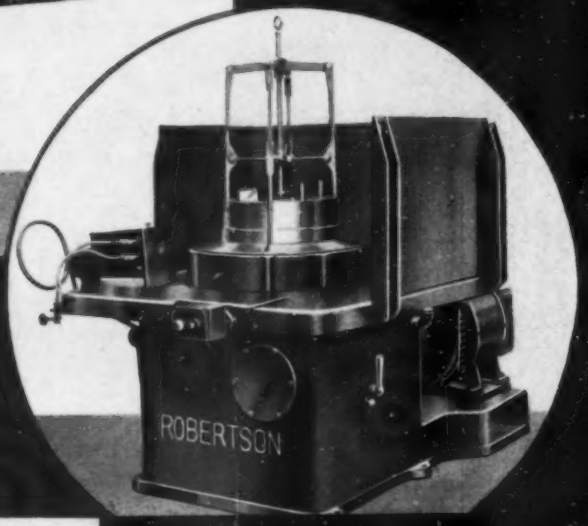

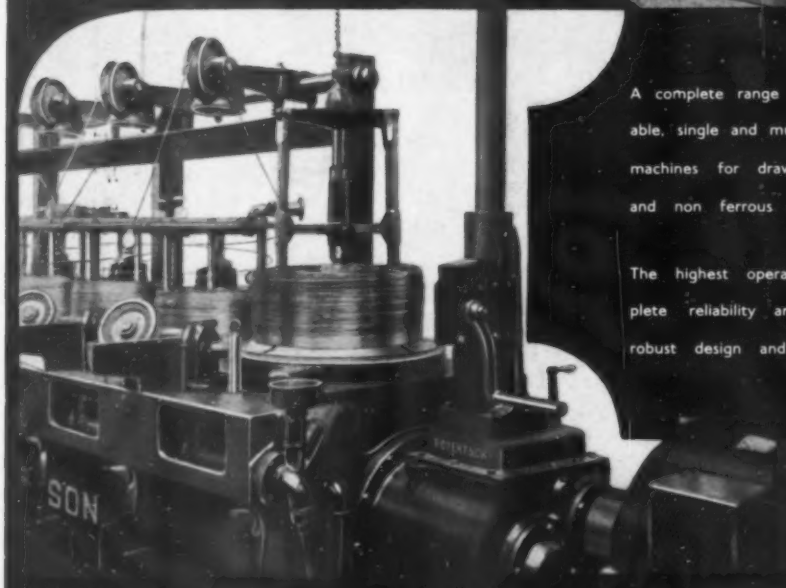

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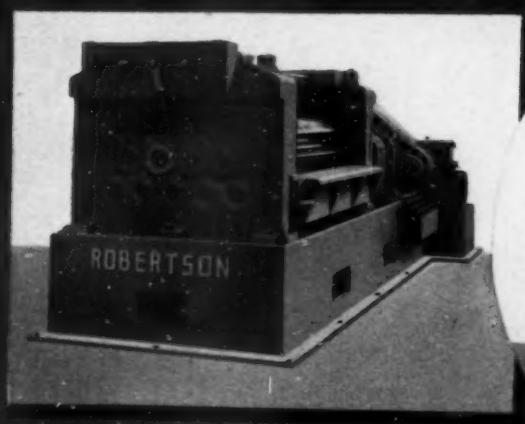

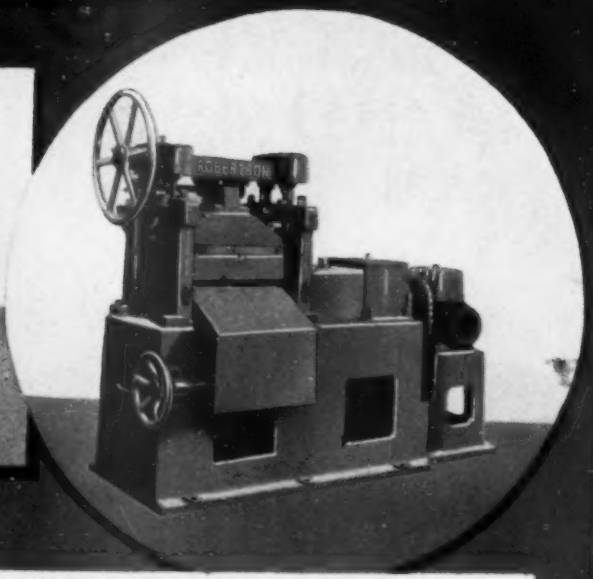

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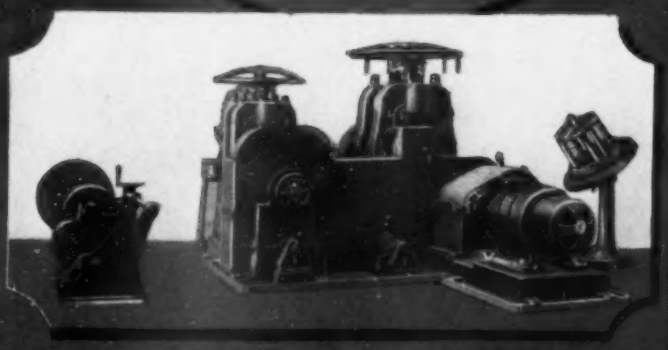

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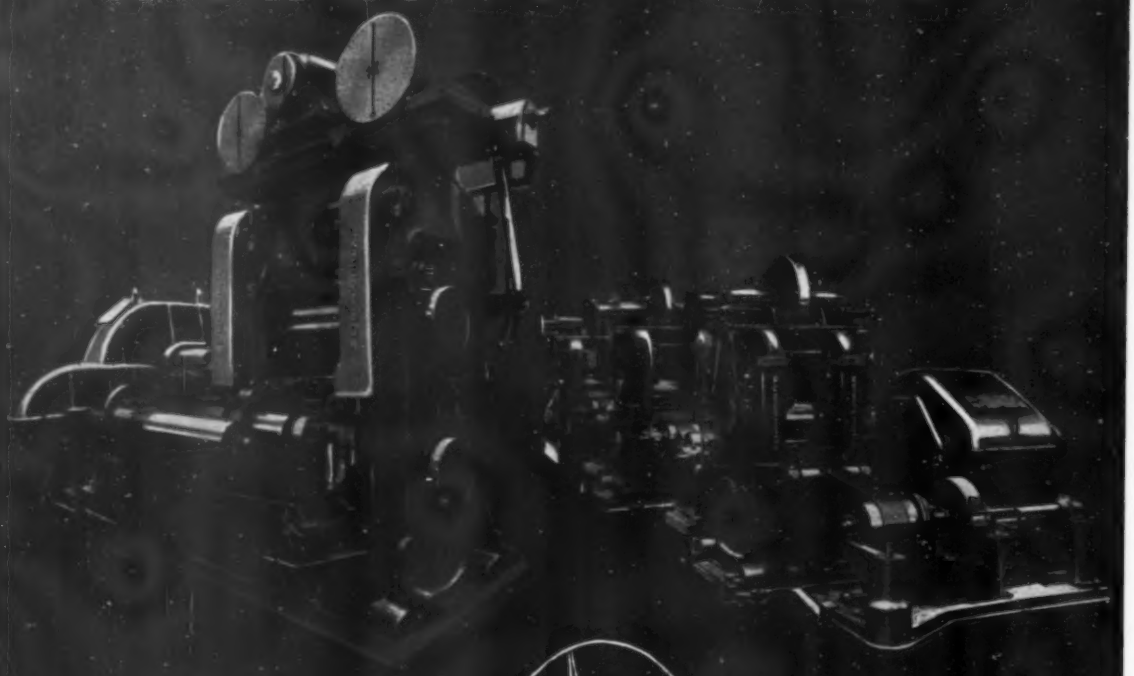

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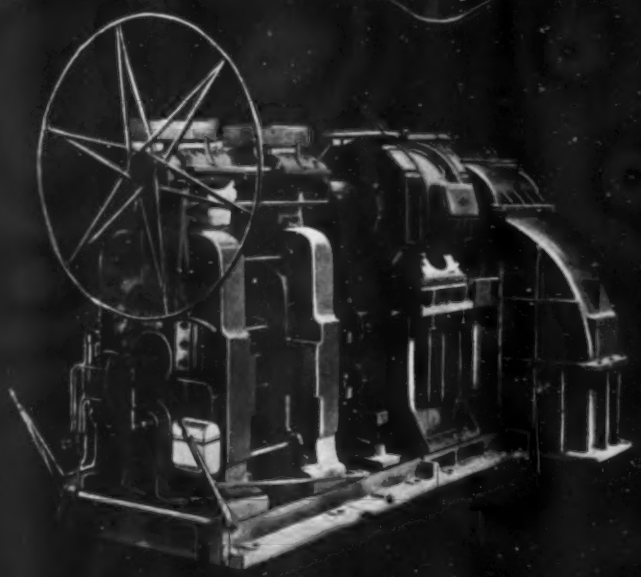

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The Effect of Casting Temperature on the Primary Microstructure of Cast Irons. Theories of Dendrite Formation and of the Solidification of Iron-carbon Alloys

IN the course of a previous investigation* a number of different compositions of white cast iron were tested, and it was noted that differences in casting temperature had a remarkable effect on the fracture of hypereutectic white irons. If cast very hot the fracture was coarsely crystalline. If cast very cold it was finely crystalline and granular. Microscopic examination showed corresponding differences in the size of the primary carbide plates. In hypoeutectic white irons no such differences were visible from the fracture, but microscopic examination again showed extremely interesting differences in the primary microstructure, due to differences in casting temperature. Such differences were subsequently studied in detail in the case of these white iron compositions and also in grey iron compositions. They are illustrated in this paper by Dr. A. L. Norbury, and form the basis of the description and discussion which it contains.

The microstructures are interpreted as showing that primary dendrites result from the joining up of globules, and that large primary plates result from the joining up of smaller plates. This may have a bearing on the " mosaic " structure in crystals. Lower casting temperature refined the dendritic structure of ordinary (γ-iron) compositions of grey cast iron in a similar manner. In the case of 14% silicon (δ-iron) grey iron compositions, however, it had no refining effect comparable with the above. This difference is attributed to the recrystallisation of γ-iron on solidification, due to the occurrence of the $\delta \rightarrow \gamma$ allotropic change and to the non-recrystallisation of δ-iron, both being assumed to be in the δ-iron allotropic condition in the liquid state. In the same way, it is suggested that pure carbon is in the diamond allotropic form in the liquid state, and solidifies without allotropic change when diamond is formed, but with allotropic change when graphite is formed. In cast iron compositions, carbon is similarly assumed to be in the diamond form in the liquid state, and to form a diamond-iron compound (iron carbide) when it solidifies without allotropic change, but to form graphite, as above, when it solidifies with allotropic change.

In an Appendix, it is suggested that elements in solid solution graphitise cast iron, while those forming compounds stabilise the carbide.

Tensional Effects of Torsional Overstrain in Mild Steel

THE usefulness of a material for manipulative processes such as deep-drawing, in which severe plastic deformation is involved, depends primarily on the range of plastic flow to which it can safely be subjected. This depends in turn on :—

(1) The impressed conditions necessary for the inception of plastic strain in the material ;

(2) The stress-strain characteristics for the material in the plastic range ; and

(3) The cohesive properties of the material which resist rupture.

The so-called conditions of elastic breakdown have been the subject of much study and controversy. Several theories still have their champions, but modern opinion seems generally to regard maximum stress as the criterion of breakdown for brittle materials and shear-strain energy (or shear stress on the octahedral planes, to which this is implicitly related) for ductile materials. That there should be any conflict between theories for brittle and theories for ductile materials indicates a confusion of ideas as between conditions necessary to produce plastic strain and conditions necessary to produce rupture. In brittle materials the conditions of rupture commonly intervene before those of plastic flow ; in ductile materials plastic flow occurs long before the conditions of rupture are reached. Since plastic strain is of primary interest in this paper by Dr. H. W. Swift, shear energy is regarded provisionally as a working criterion of its inception.

The conditions of rupture are discussed in the light of accepted facts ; it is suggested that rupture in mild steel may occur either by tensile or by shear stress and that overstrain tends to weaken the metal in shear in a directional manner.

Results are given of tensile tests on mild-steel bars previously subjected to various degrees of torsional overstrain. These results support the conclusions that the inception of plastic flow is affected by the internal stress distribution as well as the general " scalar " condition of the material as measured—for example, by its hardness number. The relationship between shear stress and shear strain in the plastic region is not independent of the system of applied stress. The plastic stress-strain relationship under tensile conditions, although affected in its earlier stages by previous strain-history, becomes independent of this as straining proceeds. Rupture may be caused (*a*) by tensile stress, (*b*) by shear stress, or (*c*) possibly by a combination of tension and shear. Resistance to rupture by shear stress is modified directionally by overstrain. No positive evidence is furnished regarding the effect of overstrain on resistance to rupture by tensile stress, but there are indications that any such effect is small. Neither strain energy nor hardness is a controlling factor in regard to rupture, nor does either of these quantities define the resistance of the material to plastic strain in the general sense. The reversal of torsional strain has certain remedial effects on the apparent shear strength under tensile conditions, due possibly to the masking of directional properties.

* A. L. Norbury and E. Morgan, *Journal of the Iron and Steel Institute*, 1936, No. II, pp. 327-358.

Iron and Steel Institute Awards

The majority of readers will be familiar with the various prizes awarded annually by the Council of the Iron and Steel Institute, and, in view of the restrictions now imposed by war conditions, it is possible that some may desire to direct their energies and time to an achievement of this character. We would remind those readers that the Council have announced the following prizes will be awarded :—

The Council have accepted an offer from Captain C. A. Ablett, O.B.E., B.Sc., M.Inst., C.E., to present a prize of £50 for the best paper on a subject connected with engineering in iron and steel works submitted to the Institute, written by a junior engineer, irrespective of whether or not he is a member of the Institute.

The Williams Prize to the value of £100 is presented annually, subject to the discretion of the Council, to the author of a paper of a practical character adjudged by them to be the best paper of that character presented to the Institute and accepted for publication during the year.

Andrew Carnegie Scholarships, usually to the value of £50 or £100 are awarded annually by the Council in order to assist those engaged in research, irrespective of sex or nationality. Candidates must be under 35 years of age.

Full particulars of these awards may be obtained from the Secretary, Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1.

Shotts on Full Production

The Shotts Iron Company, Ltd., of Shotts, Lancashire, has started on full production two blast furnaces which were damped down a month ago. One furnace which was reconstructed some years ago remained in operation on the production of basic steel making iron, but the units damped down are unsuitable for turning out this grade, and concentrate on foundry quality.

A scheme to encourage the local production of basic pig iron by covering certain transport charges was proposed by the Britiah Iron and Steel Federation some time ago, and it is understood that the Shotts firm has participated.

Ninth Report on the Heterogeneity of Steel Ingots

THEORY AND PRACTICE OF RIMMING STEEL MANUFACTURE

The theory of rim formation in steel ingots is discussed; further studies of the composition variation of rimming steel are given, and notes are submitted on typical practice in the manufacture of rimming steel ingots in British steelworks. The Report is by a Joint Committee of the Iron and Steel Institute and the British Iron and Steel Federation.

CONSIDERABLE attention has been given to rimming steel in previous reports by the Joint Committee of the Iron and Steel Institute and the British Iron and Steel Federation to the Iron and Steel Industrial Research Council. Ingots of this type were included among those examined in the series of researches which were started soon after the formation of the Committee in May, 1924, the object of which was to determine the nature and degree of the heterogeneity commonly found in ingots of different types. As a result of these researches investigations were started designed to ascertain the causes of heterogeneity and to provide the knowledge needed to control it in steelmaking; these investigations necessitated increasing attention being given to the problems of theory and practice which are involved in the manufacture of a steel ingot with a solid rim.

This work was facilitated by the investigation put in hand by the Liquid Steel Temperature Sub-Committee, the Ingot Moulds Sub-Committee and the Oxygen Sub-Committee, and by the numerous researches carried out by individual members of the committee, and particularly those on gases in steel which were put in hand before the formation of the Oxygen Sub-Committee. Attention is especially directed to several important papers on rimming steel in other countries during recent months, notably those by Chipman and his colleagues and by Hultgren and Phragmén,[1] which have decided the committee to formulate their ideas on the subject in this special report. Three papers are published in the report: the first reviews the theoretical discussion of the process of solidification of iron-carbon-oxygen alloys put forward by Hultgren and Phragmén; the second presents further studies of the composition variation of rimming steel from outside to centre; and the third deals with British practice in the manufacture of rimming steel. Although the authors of these papers are alone responsible for the views expressed, the committee are confident that these views will be found of general interest.

Theoretical Discussion of the Process of Solidification of Iron-carbon-oxygen Alloys

This contribution by Dr. C. A. Edwards deals with that part of Hultgren and Phragmén's paper[2] on the solidification and structure of rimming steel ingots which specifically relates to the theoretical aspects of the solidification of rimming steel. These Swedish authors have attempted to incorporate all the available evidence concerning the influence of varying amounts of carbon and oxygen on the freezing of iron-carbon-oxygen alloys in the form of ternary diagrams, and in this way are able to give a more systematic outline and clearer vision of the problem than previously existed.

Dr. Edwards endeavours to bring out the more salient features of Hultgren and Phragmén's work, particularly that part relating to the theoretical discussion of the process of solidification of which a complete extract is given. He recognises that many factors of considerable importance are not referred to in this paper, but he feels that these factors can only be profitably discussed after something like agreement has been reached concerning the effects of carbon and oxygen upon the solidification of rimming steel. From Hultgren and Phragmén's paper and the extremely useful diagram contained in it, which is reproduced in the present paper, it is possible to follow the changes that occur during the solidification of rimming steel, and to understand how these vary when different percentages of carbon and oxygen are present.

Rimming Steel. Further Studies of the Composition Variation from Outside to Centre

This paper by Dr. Swinden gives the results of further studies of the composition variation of rimming steel from outside to centre, and is a continuation of the author's work published in Section II of the Committee's Seventh Report, in which was given a detailed study of the variation in the carbon, manganese, sulphur and phosphorus in a billet of open-hearth rimming steel containing 0·16% carbon, and in an ingot of basic Bessemer steel. Dr. Swinden gives details of a further investigation of the same Bessemer ingot, including the following supplementary data: (*a*) Inclusions, a detailed microscopical study; (*b*) Brinell hardness; (*c*) oxygen and nitrogen contents by the vacuum fusion method. In addition, a detailed study of a basic open-hearth rimming-steel ingot has been made by the examination of cross-sections of a 10½-in. bloom. These have been examined by (*a*) microscopical examination, (*b*) chemical analysis for carbon, manganese, sulphur and phosphorus, and (*c*) vacuum fusion tests for oxygen, hydrogen and nitrogen. The author also discusses factors influencing segregation of the elements in rimming steel in the light of contemporary work.

Practice in the Manufacture of Rimming Steel

In this section of the report a number of papers give details of the practice employed at representative British steelworks for the production of rimming steel. The details embrace practice using acid Bessemer, basic Bessemer and basic open-hearth processes; the first of the papers being by Dr. T. Swinden and Mr. F. B. Cawley, who deal with the manufacture of rimming steel at Workington by the acid Bessemer process; the basic Bessemer process at Corby is presented by Mr. W. L. Kerlie; several papers deal with the manufacture of rimming steel by the basic open-hearth process including one by Mr. N. H. Bacon, on practice at Templeborough, the practice at the Lancashire Steel Corporation is detailed by Dr. D. Binnie; at Normanly Park Works by Mr. J. B. R. Brooke; that at the Cardiff works of Guest, Keen, Baldwins Iron and Steel Company is contributed by the company; Mr. J. Gibson deals with practice at Glengarnock Iron and Steel Works, some notes are given by Mr. J. S. Lewis on practice at Briton Ferry, using cold pig-iron and scrap in manufacture; and practice at Bilston is given by Mr. R. S. Rolfe.

The factors necessary for the accurate control of the steelmaking and the rimming action are clearly brought

[1] See Hayes and Chipman, American Institute of Mining and Metallurgical Engineers, 1938, Technical Publication No. 988: *Metals Technology*, 1938, Vol. 5, Dec.; Hultgren and Phragmén, *Jernkontorets Annaler*, 1938, Vol. 122, No. 8, p. 377.

[2] *Jernkontorets Annaler*, 1938, Vol. 122, No. 8, p. 377.

out in these papers, and it is shown that while there is a general similarity in the method employed, there are differences as between different works due to variations in the raw material and in the process employed. In a concluding paper by Mr. J. Mitchell the important practical aspects of rimming-steel manufacture, as brought out by descriptions given in the other papers, are discussed from which the following abstracts are made.

General Survey of the Practical Aspects of Rimming Steel Manufacture

When cast from the ladle into the mould, rimming steel exhibits a vigorous effervescence, and from the open mould top there is a constant spray of fine particles blown up by the gas evolution. When the metal is in proper condition, the steel freezes inwards from the mould walls, and the evolution of gas continues until only a small liquid core remains. An ingot of this type may be referred to as a "fully-rimmed ingot." It is generally recognised that, if the metal is in a proper condition, there is no rise or fall in the mould—i.e., the steel proceeds to rim-in flat at the level to which the mould was filled.

The rimming process just described gives material with a maximum thickness of pure envelope for any given carbon content. In certain cases, it is usual to suppress the rimming action by throwing a plate on to the effervescing surface when the desired thickness of envelope has been obtained. Yet another variation in practice of this kind is to have the metal in such a condition that it rises in the mould after filling, and the depth of filling is so regulated that the metal rises and chills against a cap, which again suppresses the rimming action—in this case with a comparatively thin outer envelope of pure material. It is generally agreed that these variations in practice may be applied, as is desirable, when there is a knowledge of the ultimate use to which the steel is to be put.

The first point to be noted with respect to the manufacture of rimming steel is that the success or failure of the rimming operation is dependent on the condition of the metal—primarily as regards the temperature and degree of effervescence. So far as temperature is concerned, it is generally found that steel which is cast too hot, even if the conditions of manufacture have been otherwise correct, will not give satisfactory results. Very hot metal remains comparatively quiet in the mould until too late a stage, when it is inclined to rise and effervesce vigorously without the necessary time being available for the reactions to proceed to completion. Metal which exhibits too vigorous an effervescence subsides too rapidly in the mould, and the subsequent rimming action is unsatisfactory. This difficulty can be readily overcome by the use of a few pellets of aluminium. On the other hand, metal which exhibits a weak effervescence tends to rise immediately the mould is filled. The significance of this rising action is that gas holes have been entrapped too early in the freezing envelope, and, in consequence, indifferent surfaces will be obtained on the subsequent rolled product. It is by no means easy to correct material which effervesces too weakly, but a certain measure of success has been obtained by the use of sodium fluoride.

Material required for the casting of rimmed-steel ingots is normally made by the Bessemer process (acid or basic), or in the basic open-hearth furnace. There is general agreement among practical steelmakers who have had experience of both types of process that a controllable rimming action is more readily achieved with the Bessemer methods than with the open-hearth. The outstanding practical requisite in all processes is a boil of the right nature and of sufficient duration during the steelmaking operation.

It would appear that in the basic open-hearth very close control of the melting and operating conditions has to be applied in order to produce the desired type of reaction, whereas in the Bessemer process this appears to be achieved more or less automatically. It is abundantly clear, from the descriptions of all the processes, that the boiling action required is produced not so much by the presence of excess of oxide as by having the correct amount of oxide during the boiling period. There is, in fact, a relationship between the reaction of oxide available and the behaviour of the metal which must be observed if satisfactory rimming conditions are to be obtained.

A general study of the composition of the slags at the beginning of the operation shows that, as a rule, they are higher in silica than the finishing slag, and contain relatively little iron oxide before the iron-oxide additions are made. It is common experience also that, in the finishing slag, the lower silica is accompanied by a rise in the oxide of iron present, the lime remaining, for all practical purposes, constant. This would seem to indicate that, in general terms, for the control of the reaction the starting point should be the silica percentage of the slag. This is recognised explicitly in some of the contributions, and can be read into the figures which are given in others. It would appear that it is necessary to carry a somewhat higher percentage of FeO in the finishing slags of the basic open-hearth than it is of the basic Bessemer.

Apart from the state of oxidation, there is evidently a general opinion that the rimming action in the moulds will be affected by the percentage of various other elements present in the metal, even before the deoxidisers are added.

There appear to be differences of opinion as to what constitutes the most suitable composition of the bath, more particularly with regard to the maganese content, but there is general agreement that the blown metal and the metal after finishing should contain no silicon. It is suggested, in some cases, that the sulphur may have an effect on the rimming action, but this is a factor, if it is so, that is probably related to the manganese content of the material.

The type of deoxidiser employed and the quantities in which it is used are of great importance. In making very low-carbon material, ferro-manganese, frequently of the low-carbon variety, is employed, although in the case of Bessemer heats spiegel is also used. It appears also to be general practice in the open-hearth to use a percentage of aluminium in the ladle to bring the metal to the point at which the mould effervescence can be controlled by the use of small quantities of the same material in pellet form. A similar practice is unnecessary in the Bessemer heats.

Both top and bottom filling are used in Britain. With uphill teeming, a rather more vigorous effervescence is necessary than with top-teeming. It is interesting to speculate as to whether the turbulence produced by the filling, in the case of top-teemed ingots, assists in the mechanical movement apparently necessary to the rimming process. One of the features of rimmed, as compared with solid steel is the ease with which excellent surfaces can be obtained on the rolled product. In view of this, it may, at first sight, appear illogical to go to the expense and trouble of uphill casting. For special-quality work, however, it is the author's opinion that there are two good reasons for the practice: (*a*) The elimination of splash; and (*b*) the control of the filling rate.

Mr. Mitchell concludes that this general study of practice in the preparation of rimming steel in Britain throws into relief the essentials of successful operation. In the first place, the furnace practice must be such that the material is prepared by means of a properly-controlled boil. The importance of accurate control, usually effected through the slag composition and judicious use of deoxidisers, is clearly brought out. The production of rimming steel is an art demanding accuracy of control, and the product is not, as is sometimes too loosely assumed, material melted and cast into moulds at random with a minimum of finishing addition.

Special Report No. 27. Ninth Report on the Heterogeneity of Steel Ingots; published at the Offices of the Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1. Price 10/- (Members, 5/-).

Some Works on Clydeside

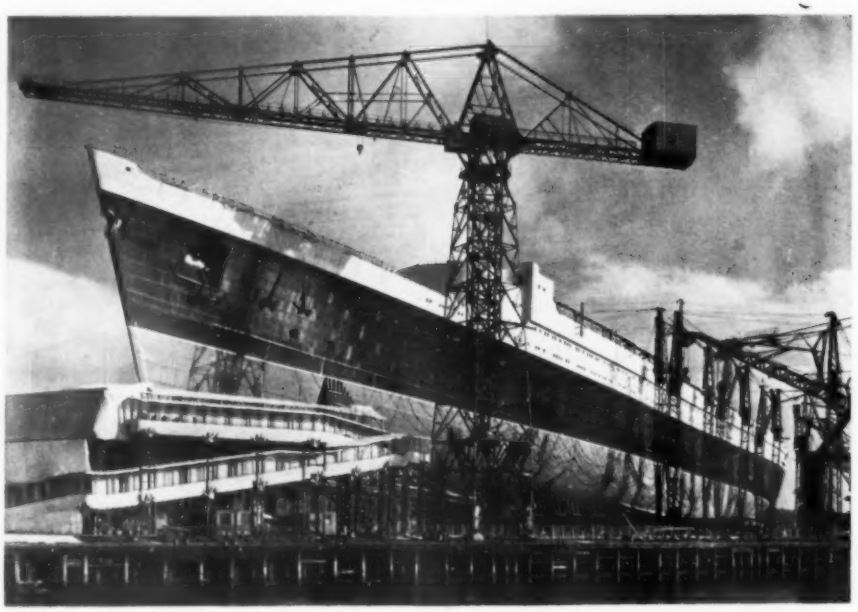
The Valley of the Clyde: A Great Industrial Area

Brief descriptive references are made to some of the works included in the visits arranged in connection with the Autumn Meeting of the Institute of Metals at Glasgow, which was subsequently cancelled.

SITUATED in the centre of the great industrial valley of the Clyde, Glasgow is an admirable city in which to hold an annual meeting of a technical institute, such as that of the Institute of Metals. Quite apart from the fact that this Institute has a useful contingent of live members in the area, who can be relied upon to make such a meeting a success, the city is the centre of so many industries of varying character that the selection of works included in any programme of visits, during the short time available at such a meeting must be a difficult problem.

For centuries Glasgow has been a centre of business and industry; its foreign trade is said to have begun early in the 15th century, and a hundred years later trading was carried on with Poland, France and Holland. The weaving of cotton was started in 1780 and three years later cotton mills were set up at New Lanark and elsewhere. Great impetus was given to this and other industries by James Watt's improvements in the steam engine, following which came the invention of the steamboat, and by 1789 a steamer was running on the Forth and Clyde Canal. Then the first passenger steamer, the *Comet*, was launched on the Clyde in 1812, and so began the great modern shipbuilding and shipping industries of Glasgow. Next came the demand for ships of iron and steel. Until the end of the 18th century nearly all the iron used in Great Britain was imported. Dr. Roebuck, of Sheffield, had established the great ironworks at Carron, in 1760, and 26 years later the Clyde Ironworks was founded at Glasgow. A little later, in 1801, Robert Musket discovered the rich seams of clayband ironstone in the Clyde valley, which gave a great impetus to the iron industry in this area.

These few notes should be regarded in the nature of a thumb-nail sketch of the industrial beginnings of Glasgow, and its environs which led to its greatness; to-day there are few industries not carried on in this area; the difficulty in making a selection, therefore, will be readily understood, but brief descriptive references to some of the works included in the programme of visits will be of interest.



Courtesy of John Brown and Co., Ltd.

A vessel on the slipway at John Brown's, preparatory to launching.

Messrs. John Brown and Co., Ltd.

FEW of the world's shipbuilding centres are better- or more widely-known than the Clydebank establishment of Messrs. John Brown & Company, Limited. The history of the firm may not be quite as ancient as that of some others on the famous river, but in point of achievement and capacity it comes an easy first and stands well in the van of the world's greatest industrial companies. The Clydebank Works had their origin in a small factory in the City of Glasgow in 1846 and the present establishment, situated about seven miles west of Glasgow, was first laid out in 1873. From the beginning, the expansion of the firm has been steady and continuous, and the Clydebank Yard of to-day, the birthplace of the world's greatest and fastest liners and most powerful warships, occupies a foremost place in naval and mercantile shipbuilding.

At Clydebank the shipbuilding berths, engine shops, turbine shops, boiler shops, wood-working shops and the subsidiary establishments and buildings cover an area of approximately 80 acres and can provide employment for fully 10,000 men, but, in spite of its vast size, it is yet one of the most compact establishments of its kind and the range of work which it is capable of doing is exceptionally wide. The site of the Yard is one of the best, and the berths have been arranged to accommodate vessels of the largest size and weight. On the east side of the large fitting-out basin are situated the five large berths, two of which are capable of taking ships of 1,000 feet in length, and the launching problem is simplified by launching the vessels across the Clyde into the mouth of the Cart, one of the largest tributaries. On the west side of the fitting-out basin there are three other building berths, one of 500 feet in length and two special berths completely covered-in, capable of taking vessels up to 450 feet in length. The latter are excellently adapted for vessels of a special character such as light cruisers, torpedo boat destroyers, submarines and large steam yachts of which Clydebank have built quite a number.

The firm were amongst the first in this country to possess a fitting-out basin of their own and so thoughtfully has its extension been carried out that for no ship built at Clydebank has it ever been found wanting in length, depth of water or equipment. Two large cranes provide

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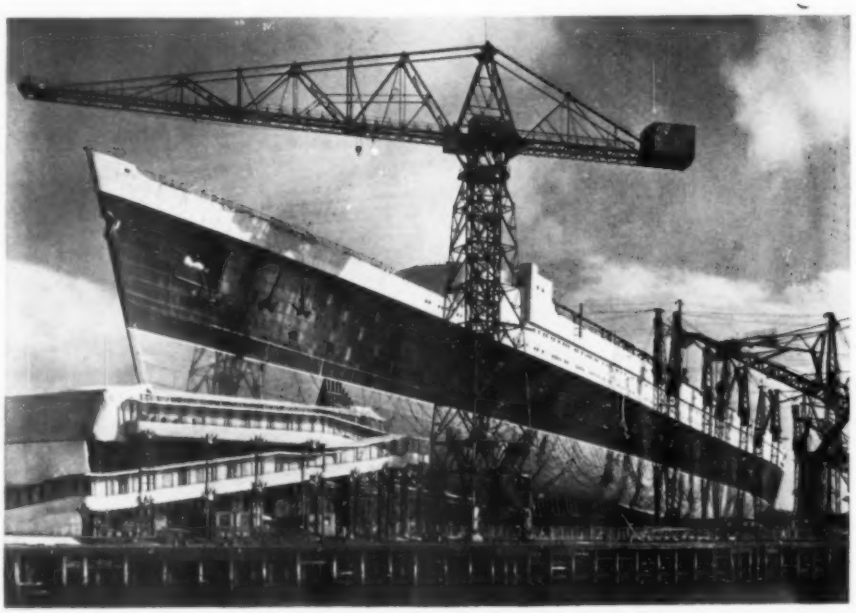

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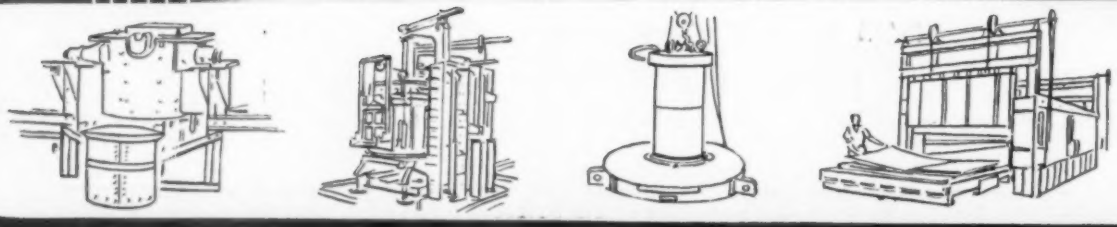


Advt. of The General Electric Co. Ltd. Head Office: Magnet House, Kingsway, London, W.C.2.

facilities for dealing with loads up to 150-200 tons. No higher tribute could be paid to the enterprise of the directors of the Company than to record that this basin has sufficed for such vessels as the *Lusitania*, *Tiger*, *Aquitania*, *Barham*, *Repulse*, *Hood*, *Empress of Britain*, *Queen Mary* and *Queen Elizabeth*.

The equipment of the Yard and fitting-out basin is of the most up-to-date character and not only fulfils present requirements but also anticipates new ones. The lay-out is admirably designed, and shops and other buildings devoted to the preparation of material being so arranged and served with hoisting gear and transport facilities that the flow of material from the work sidings to the ships' sides is steady and continuous.

One of the most interesting departments in the Yard is the Experimental Tank which the firm installed many years ago and which has played a great part in the development of the scientific side of the industry. Here the models of the vessels are run to determine the powers necessary, and complete investigations are made into all the problems of propulsion. The remarkable successes which the firm have achieved in all their results with vessels of the highest power are in a large measure due to the painstaking care which they have exercised in research of all kinds.

The fitting and erecting shop is conveniently situated immediately adjacent to the machine shops with which it is directly connected by a line of railway. The shop is divided into three well-lighted bays, the largest about 230 ft. in length and covering in all an area of about 35,000 sq. ft. Six overhead electric cranes, four with a capacity of 80 tons each, and two with a capacity of 60 tons each, enable the heaviest parts of turbines and reciprocating machinery to be handled expeditiously. In addition to the electric cranes a number of hydraulic jib cranes are fitted to the shop columns to facilitate the handling of of smaller parts about the floor. Among the large sets of machinery that have passed through these shops may be mentioned the geared turbine machinery of H.M.S. *Hood*, developing 150,000 shaft horse power and the turbines for R.M.S. *Aquitania*, while the culminating achievement in point of power output has been attained in the machinery installed in the *Queen Mary* and the *Queen Elizabeth*.

The ships which stand to the credit of Clydebank in the records of the industry cover so wide a range in time and type that there is scarcely a year passes without the production of some new wonder. In the case of Atlantic liners the *Servia*, *America*, *City of Paris*, and *City of New York* all stirred the maritime community in their day and were acclaimed ships of unusual merit which was in every case confirmed by their subsequent service. In the later days the famous Cunarders *Caronia* and *Carmania* were built, the latter being one of the first large liners to be fitted with steam turbines, and there quickly followed the renowned *Lusitania* which marked another stage in the progress of shipbuilding, while just before war was declared in 1914, the Company had completed a still larger Cunarder, the *Aquitania*. The satisfaction which these vessels have given to their owners is indicated in the fact that the orders for the *Queen Mary* and her sister ship the *Queen Elizabeth*, the largest and finest examples of this type of ship, were placed at Clydebank.

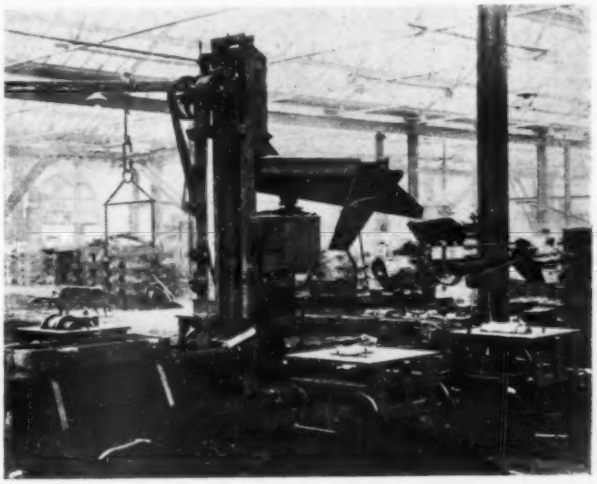
Another company which is well represented in the Atlantic traffic by Clydebank vessels, is the Canadian Pacific Steamships, Ltd., whose latest acquisition, the *Empress of Britain*, is one of the most luxurious ships ever produced, and whose *Duchess* Class, three of which are from Clydebank, are also eminently successful ships. Besides these great liners for the Atlantic routes, many notable merchant vessels have been built at Clydebank, for other ocean services, while in the channel and cross-channel services of the United Kingdom there is hardly a route that does not have Clydebank vessels operating.

Any mention of the firm's products would be incomplete without reference to their record of warship production. As far back as 1885 the firm launched their first vessel of war, the third-class cruiser *Scout* and their subsequent contracts for all kinds of warships make a long list.

Altogether, the history of the firm in the past has been one of uninterrupted success, of which any company might be proud, and the management has shewn clearly, by the extent and variety of its resources that the establishment at Clydebank is capable of carrying out the largest and most exacting demands which the future is likely to make upon it.

Glenfield and Kennedy Ltd.

CLAIMED to be the largest works in the British Empire devoted exclusively to the manufacture of hydraulic control structures Glenfield and Kennedy Ltd. can be said to have had its inception in 1852 when a syndicate was formed to acquire the patent rights of a water meter which was the invention of a Kilmarnock gunsmith, Thomas Kennedy. The original Glenfield Company commenced its activities as ironfounders in 1865 and occupied part of the site on which the works now stand. In 1869 the Kennedy Meter Company purchased land from the Glenfield Company and the meter works moved to the present site although still a separate concern. The products of the two Companies were allied and sold in the same fields and close working arrangements were established. A fusion of the two Companies was a natural development and the interconnected interests of the Glenfield Company and the Kennedy Meter Company were therefore merged in 1899, and the present Company was formed.



Sand slinger moulding machine in the repetition foundry of Glenfield and Kennedy, Ltd.

Commencing with small works and employing very few men, the firm now owns over 100 acres of land, of which 30 acres are occupied by workshops and the number employed now approaches 2,000. From being exclusively devoted to the manufacture of water meters, allied products used in waterworks systems, such as sluice valves and fire hydrants, were soon being made. By gradual and consistent development, the range of products was increased until every type of equipment for the control and measurement of water is now included in this firm's output. In order to secure the requisite high degree of accuracy in manufacture, with economy and rapidity of production, each class of product is constructed in shops specially equipped with the most suitable machinery and plant.

The iron foundries rank among the best equipped in the country and have a combined capacity of 400 tons per week. The heavy foundry can produce castings weighing up to 30 tons. It is equipped with a casting pit in which work up to 40 ft. long can be cast vertically. Crane power

Courtesy of Glenfield and Kennedy Ltd.

Part of the General Engineering Department of Glenfield and Kennedy Ltd.

up to 60 tons capacity is provided. This foundry is equipped with a portable sand slinger suitable for the heaviest class of work. Large core ovens are heated by hot air from forced draft coke furnaces. The light foundry is equipped with a complete sand conditioning plant, having a weekly capacity of 1,000 tons; a sand slinger; and moulding machines, each having a capacity of 1,500 lb.; in addition, lifting and transporting facilities of ample capacity.

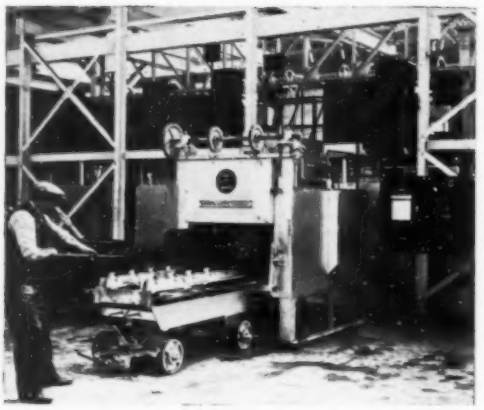
Melting facilities are provided by four cupolas, each capable of providing molten iron at rates of 3 to 12 tons per hour. Recently a 5-ton oil-fired Stein and Atkinson rotary furnace has been added. This furnace is used for the production of high-duty iron and special iron alloys of austenitic character, principally for corrosion resisting purposes. It is noteworthy that for some time the whole of the output of these foundries has been of Mechanite cast iron, except for special alloys, a considerable quantity of which are regularly cast.

The brass foundry was recently greatly extended and completely re-equipped with modern furnaces, among which is a 2-ton rotary furnace similar to that installed in the iron foundry. The output of non-ferrous castings is up to 25 tons per week and castings up to 3 tons are made.

Expert scientific control is employed in all the foundries, sands and metals being under regular technical supervision. A modern fully-equipped physical and chemical laboratory exists for this purpose, under the control of an expert staff. It is a self-contained building, and, in addition to providing facilities for the routine checking of the iron and non-ferrous alloys produced in the foundries, it is laid out for research work on subjects related to the hydraulic engineering industry.

The machine shops are divided into departments equipped for dealing with particular products. The light department, for instance, is equipped for the production of all classes of cast iron, cast steel and gunmetal valves up to 13-in. diameter. The valve department produces all types of sluice valves from 14-in. to 48-in. diameter, including electrically and hydraulically operated valves and automatic valves of these sizes, medium-sized sluices, and various types of large diameter reflux valves. Valve towers of moderate dimensions are also built in this department.

An important addition was made to these works in 1929 when the general engineering department was opened. All heavy hydraulic control plant is manufactured in this department, as well as valves of the largest diameters. It deals with the manufacture of hydro-electric and irrigation control equipment, such as needle valves, sluice valves, sluice gates, butterfly valves, large tilting disc reflux valves and automatic self-closing valves of all kinds.



Courtesy of Albion Motors Ltd.

Low-temperature tempering furnace with tray of gear which is in course of removal.

Albion Motors Ltd.

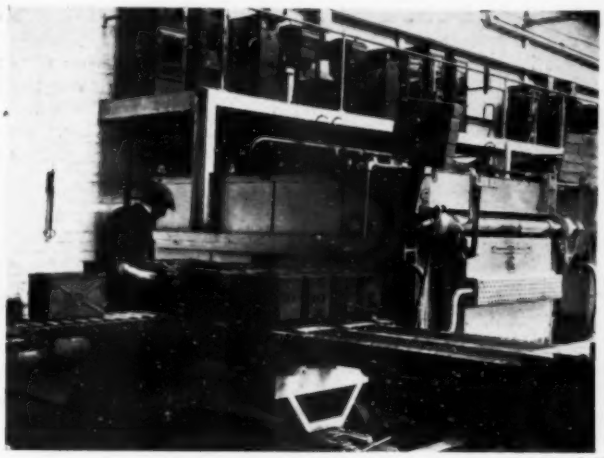
IN December, 1899, the Albion Motor Car Co., as it was then called, was founded by Mr. T. Blackwood Murray and Mr. Norman O. Fulton, two young engineers who were fired with enthusiasm for the new form of locomotion represented by the automobile and who possessed the vision of pioneers. Towards the end of the year 1900 the first Albion was driven out on test. It was an 8-h.p. "dog-cart" with tiller steering, a horizontally-opposed 2-cylinder engine, and low-tension magnetic ignition. This machine was the forerunner of the thousands of lorries, vans and buses which bear the name Albion today.

A steadily increasing demand for machines soon made it necessary for the Albion Company to find larger premises, and a site was found at Scotstoun, about four miles from the centre of Glasgow. Here the beginnings of the present factory were built and in the summer of 1903 manufacture commenced in the new works. During the early years of its existence, the Company built both pleasure and goods vehicles, but as the industrial market grew in importance more attention was given to it, and, in 1912, the directors decided to drop the private car business and to concentrate entirely on the manufacture of commercial vehicles.

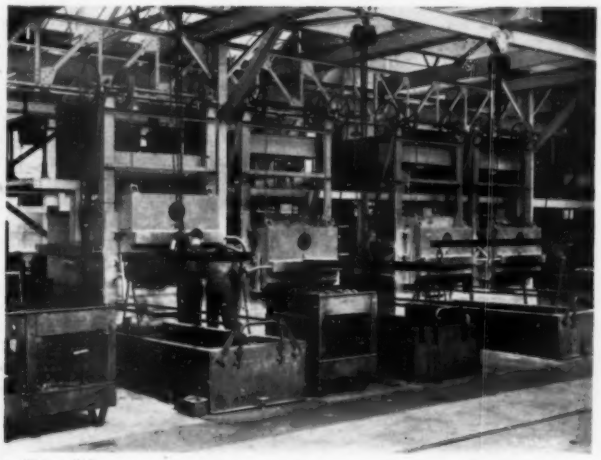
With the increase in the demand for commercial vehicles and the introduction and development of road coaches, the works were extended to cope with growing orders for Albions. A considerable overseas business had been developed, particularly in India, Ceylon, New Zealand, Australia and Canada, necessitating further works development. The outbreak of war in 1914, however, resulted in the factory being concentrated on the 32-h.p., 3-ton model for the War Office and nearly 6,000 vehicles of this type were supplied. During the period from 1914 to 1918 the works were further extended and production increased to between 45 and 50 vehicles per week. Today, the works at Scotstoun have a manufacturing floor space of over 11 acres and employ nearly 2,500 people.

Owing to the wide range of models and sub-types produced, the general principle adopted in the Works' organisation is to manufacture parts for stock so that not only standard chassis, but also special types, can be built with the minimum of delay. This method imposes great responsibility on the stores and increases the magnitude of its organisation; this is appreciated when it is realised that considerably over 16,000 different kinds of parts are regularly turned over in the stores at the rate of 70,000 parts per week from the machine shops, in addition to parts obtained from outside sources.

In the main machine shops, separate sections are devoted to such heavy parts as rear axle boxes, cylinders, and engine casings. Several other groups of machines are disposed to deal with the individual parts with the minimum of transport and take advantage of concentrated controlled attention; as, for example, front and rear hubs which are



Charger for carburising furnaces being loaded for treatment.



Courtesy of Albion Motors Ltd.

Battery of four reheating furnaces with quenching baths in front.

machined by a group of operators situated near the axle assembly bay. Machines which are not used exclusively for one particular part are grouped according to type. In another machine shop are automatic and semi-automatic lathes and a separate section dealing entirely with camshafts. Yet another shop contains a battery of gear grinders, where the change speed gear wheels are ground to ensure quiet running. A total of 370 electric motors, developing 2,500 h.p. in all, are in use in these various shops.

Case-hardening and heat-treatment of semi-finished parts are carried out in a special department. The parts are heated in electric furnaces where temperatures are accurately controlled by pyrometers which automatically regulate the heat whilst others indicate and record the the temperatures. This department has been completely reorganised and the equipment installed is of the most modern character, as will be noted in the accompanying illustrations. It is apparent that this Company appreciates the importance of heat treatment in improving the service properties of the essential components contained in Albion products.

The assembly of engine, gear box, and axle units, etc. is carried out in the Assembly Shops on a system whereby each squad of men carries out it own particular operation and then passes the unit on to the next. After assembly, the engines are tested for power and consumption on hydraulic dynamometers. They are then partially stripped for examination, closed up again and sent to the chassis Assembly to join the other units. Frame pressings, springs, etc., are stored in a two-bay building and the frames are assembled here prior to being passed to the top of the chassis assembly line close by in the long erecting shop. The various sub-assemblies, such as front and rear axles and front structure and bonnet, are to one side of the main line and flow into it.

After all the main units are assembled and the chassis can move forward on its wheels, it passes to the painting section, where it is completely sprayed. The pipes, controls, and electric wiring are then fitted and the chassis filled up with fuel, oil and water, ready for the road test. For this test the chassis is loaded with cast-iron weights and taken over a standard route, where steering, braking, hill climbing and general performance are checked by an inspector who, on his return, notes down any points requiring attention. When these have been satisfactorily dealt with, the chassis is handed over to the despatch department.

The quality of any product naturally depends very largely on the thoroughness or otherwise of the inspection system in the factory where it is made, and the high standard attained by Albion vehicles is due in a considerable degree to the great care taken to ensure that all material is of the highest grade, and that the size of every component is correct within extremely narrow limits. All inspection work is under one control. Wherever possible work is gauged at the machine, and no part is allowed to proceed to the next operation unless it conforms to the required limits. The gauges are returned to the gauge room after the completion of a job and may not be reissued until they have been minutely inspected by a special staff; the same system is applied to jigs and fixtures. All jigs and fixtures and the majority of the tools are made in the Tool Room, which is equipped with extremely accurate machines specially made for this class of work. This department is also responsible for the repair and maintenance of tools and fixtures.

Castings and forgings are bought in from specialist firms but are, except in the case of comparatively minor parts, of definitely specified materials. These parts, together with all raw material and proprietary articles, such as magnetos, lamps, carburettors, etc., are delivered to the works by road. All incoming goods are carefully examined before acceptance, and in the case of bar material, castings, and forgings, samples are sent to the laboratory for testing.

This department is thoroughly equipped to tackle the great variety of chemical and physical tests necessary to ensure that all the materials used in the construction of vehicles conform to the rigid specification in force. Included in the equipment is a high-power metallurgical microscope with camera; a 50-ton Olsen tensile testing machine; an Izod impact testing machine; hardness testing machines including a Brinell machine and a Firth Hardometer; small electric furnaces; together with facilities for the complete chemical analysis of materials.

In order that an adequate check may be kept on the work in hand and the operations in the various shops properly co-ordinated, control is vested in a progress department, which functions mainly by means of a sub-office attached to each main section of the works. Every piece of work is scheduled or dated for its series of operations and close control is maintained to get it through by the stipulated time. One of the duties of this department is that of seeing that the worker is provided with drawings, instructions, tools, etc., in addition to material to work upon, well in advance of requirements, and, of course, arranging for the removal of semi-finished material to the next operation.

New types of engines and chassis are first tried out in the experimental department, the equipment of which necessarily includes the most modern and accurate testing appliances. In this department several full power continuous runs of 300 hours form part of the many tests undergone by new engines, and, during this time, hourly readings of the temperature of cooling water, exhaust gas,

lubricating oil, etc., are taken. A chassis dynamometer is also part of the equipment on which research on the vehicle as a whole can be undertaken without it going on the road. Where temperature and other measurements are necessary under fixed conditions, another section is devoted to checking, here also, new components and proprietary parts, such as electrical equipment, carburettors, etc., are tried out, so that all possible precautions are taken to prevent inefficient or defective parts being included on an Albion vehicle.

It is apparent even to the casual visitor to these works that the careful attention to each detail and the high standard of workmanship are, in a large measure, responsible for the success achieved by this company and there is every indication that these factors will contribute to further future developments.

The Institute of Metals

The important features and results of the technical papers accepted for presentation at the cancelled Autumn Meeting of the Institute at Glasgow are discussed, and particular attention is directed to a symposium on machinability.

NORMAL peace-time activities are immediately sacrificed when a country is at war, and, in consequence of the outbreak of hostilities between Great Britain and Germany, the Autumn Meeting of the Institute of Metals, which was to have been held at Glasgow on September 5 to 8, was cancelled. This was the only course open to the Council, but it is regrettable that the excellent work done by members in the Glasgow district to make the visit to their city a memorable one to all who participated, should have been rendered futile. In many instances, these meetings provide the only opportunity for greeting friends, and it is surprising how important this aspect of the annual meetings is regarded by many members. Glasgow is the centre of the Clyde industrial area, and provides facilities for the interesting and useful works visits, that have become an essential feature of the meetings held outside London, and, in addition, some of Scotland's most beautiful scenery is within convenient reach. No doubt facilities will be provided another year for holding the Autumn Meeting of this Institute in Glasgow, where previous meetings have been successful, but elsewhere in this issue descriptive reference is made to some of the works which were included in the programme to be visited by members.

Several interesting and informative papers were due for presentation; the important features and results from the researches reported in these papers are summarised in the following notes. The complete papers have been published in the journal of the Institute, and will ultimately be contained in the bound volume of the Institute.

The Thermal Conductivity of Some Industrial Alloys of Copper and Nickel

THE results of thermal conductivity tests on three groups of industrial non-ferrous alloys are given in this paper by Dr. J. W. Donaldson. The tests were carried out to obtain reliable data on a number of alloys prepared to definite commercial specifications, the thermal conductivities of which were not available. The alloys tested were divided into three groups. In the first group were two high-tensile brasses of approximately the same composition, one cast and one rolled and annealed; two aluminium-bronzes containing aluminium approximately 8·5–10, manganese 2%, and the remainder copper, one cast and one rolled and annealed; and a third cast aluminium-bronze having the approximate composition aluminium 9·5, manganese 2, iron 3, nickel 4%, remainder copper. The second group included six alloys high in nickel.* These were a cast Monel metal; a cold-rolled Monel metal; a K Monel metal, rolled and annealed; two cast silicon-Monel metals, containing approximately 2·75 and 3·75% silicon, respectively; and an Inconel alloy rolled and annealed. The third group consisted of four cast nickel-bronzes, the first containing approximately nickel 5, tin 5, zinc 2%, remainder copper; and the other three, tin 10, zinc 1%, with 15, 30, and 50% of nickel respectively, remainder copper. Most of the alloys were to Admiralty specifications, where such specifications existed.

THERMAL CONDUCTIVITIES AT 100° AND 400° C.

Alloy.	*K*, c.g.s. Units.	
	100° C.	400° C.
Cast high-tensile brass	0·185	0·232
Rolled high-tensile brass	0·188	0·239
Cast aluminium bronze 1	0·140	0·191
Cast aluminium bronze 2	0·082	0·126
Rolled aluminium bronze	0·144	0·197
Cast Monel metal	0·064	0·084
Rolled Monel metal	0·066	0·087
Rolled K Monel metal	0·046	0·063
Cast silicon Monel metal (2·75% Si)	0·050	0·067
Cast silicon Monel metal (3·75% Si)	0·047	0·064
Rolled Inconel	0·037	0·045
Cast nickel-bronze 1	0·111	0·148
Cast nickel-bronze 2	0·087	0·120
Cast nickel-bronze 3	0·074	0·096
Cast nickel-bronze 4	0·050	0·066

The conductivity values are measured over a range of temperature from 40° to 520° C., and the results obtained are briefly discussed in relation to the various alloys and to each other. It is shown that work in the form of rolling has little influence on the heat-conducting value of an alloy. Thermal conductivities of the metals tested at 100° and 400° C. are given in the accompanying table.

The Anodic Oxidation of Aluminium

DEVELOPMENT in the anodic oxidation of aluminium and its alloys, both in Great Britain and elsewhere, has proceeded with great rapidity since it was first demonstrated many years ago. Many different types of electrolyte have been suggested, but of these three only are of commercial importance at the present time. In Great Britain the 3% chromic acid bath introduced by Benbough and Stuart is the most extensively employed, although sulphuric acid solutions are increasing in popularity, particularly for certain classes of work. The use of sulphuric acid constitutes the basis of the British-American Alumilite process, which has been widely exploited in the United States and on the Continent. Oxalic acid baths have found favour in Japan and Germany.

In this paper by Dr. J. W. Cuthbertson a report is given of an investigation on the anodic oxidation of aluminium in the above-mentioned electrolytes with the aid of the cathode-ray oscillograph. The majority of anodising baths are operated from direct current, but oxalic acid solutions frequently, and sulphuric acid baths occasionally, are arranged for alternating current operation. In this investigation alternating current has been used, but the

* The names of the alloys in this group are registered trade-marks of the Mond Nickel Company, Ltd., London.

complication involved does not detract from the usefulness of the work. The author has compared several solutions of electrolyte used in the industry and recorded marked differences in behaviour in some instances. An attempt has been made to interpret the results on a quantitative basis and to correlate new data with the theoretical and practical sides of anodic oxidation.

The effect of the oxide barrier on the form of the current-time and current-voltage curves has been studied and is shown to depend on the constitution of the electrolyte and operating conditions. Owing to a capacity effect, the current and voltage are always out of phase during the whole or a part of each half-cycle. The current-voltage curve consequently is a closed loop, the area of which is proportional to the dielectric loss in the film. The results obtained suggest that, while the mechanism of anodic oxidation in chromic, sulphuric, and oxalic acid baths is similar, chromic acid solutions should produce the more satisfactory films.

The Direct Oxidation of Zinc

THE oxidation of zinc in air and in oxygen has been examined by many workers, but only at isolated temperatures or over very limited temperature ranges. The work described in this paper by Dr. W. H. J. Vernon, Dr. E. I. Akeroyd, and Mr. E. G. Stroud has had for its main object the elucidation of the direct oxidation of zinc by systematic experiments over a temperature range of from 25° to 400° C.; these limits were chosen as being readily under control, and reasonably near to room temperature and to the melting point (419° C.) respectively.

Up to a critical temperature of 225° C. it is found that the rate of oxidation remains extremely low, but increases greatly when this temperature is exceeded. Traces of grease incorporated in the surface during polishing, and not removable by the usual degreasing, may vitiate the oxidation values; either abrasion with emery or etching with acid, with suitable precautions, yields reproducible results. Abrasion with emery gives a surface in which a certain amount of oxide, believed to be amorphous, is embedded, the reinforcement of which on heating gives a continuous film. This surface oxide film has been isolated by volatilisation of the underlying zinc. Under favourable conditions the film is extremely resistant and may permit the melting of the metal within it without rupture. Although metallic zinc leaves the surface readily at comparatively low temperatures in the absence or oxygen, volatilisation is entirely suppressed in air at atmospheric pressure at all temperatures up to 400° C.

The relationship between oxidation and time is given by the equation:

$$W = k \log (at + 1),$$

where W is the amount of oxidation in time t—i.e., except for short periods of exposure, there is a linear relationship between oxidation and logarithm of time. This relationship holds typically above, and approximately only below, 225° C., the discrepancy being the more marked the lower the temperature and the shorter the exposure. The constants k and a have been worked out over the whole temperature range and give characteristic smooth curves when plotted against temperature. It is thus possible to predict the amount of oxidation for any given temperature and time. The logarithmic type of oxidation-time curve is discussed along with the more usual parabola, with particular reference to the absence and presence of interference colours in the respective oxidation processes.

The relationship between oxidation and temperature above 225° C. is represented by the equation:—

$$d \log W/dT = - Q/RT^2,$$

a straight line (of identical slope and differing only slightly quantitatively for etched and abraded specimens) being obtained when logarithms of weight-increments after an arbitrary time are plotted against reciprocals of absolute temperature. Below 225° C. the relationship depends remarkably upon surface condition. For abraded specimens the very slight increase in oxidation from 25° C. onwards is regular and is unaffected by previous annealing. For etched (or anodically polished) annealed specimens the curve rises to a maximum (*ca.* 130° C.) and falls to 225° C., where there is a sharp point of inflection at the junction of the lower and higher temperature branches. Etched as-rolled specimens give an intermediate curve. These results are interpreted on the basis of an amorphous oxide (below 225° C.) the texture of which depends on the texture of the basis metal; the transition at 225° C. is believed to be due to crystallisation of this amorphous oxide.

The Production of Tarnish-Resistance by the Electrolytic Deposition of Beryllia, with Special Reference to Silver

THE discolouration which occurs when silver is exposed to a contaminated atmosphere has long been a disadvantage to the use of this metal, and this paper by Dr. L. E. Price and Mr. C. J. Thomas is a further contribution to the solution of this problem. In a previous paper* the authors described two methods which they had developed by which articles were given a film of alumina or beryllia. These films gave silver a very high resistance to tarnishing. Difficulty in repeating the results led to a closer investigation of this somewhat novel method of obtaining tarnish-resistance, and it was found that protection could only be obtained over a certain rather limited range of *p*H values, and that, even within this range, the form and adhesion of the deposited film varied considerably. A decrease in the polarising current during treatment led to a study of the changes in potential of the silver during cathodic treatment, and a somewhat clearer understanding of the processes involved has resulted.

The present paper, therefore, reports the results of an investigation on the conditions necessary for the production of highly tarnish-resistant films from a solution of beryllium sulphate. The *p*H of the solution must be between the *p*H corresponding to the formation of the basic sulphate $BeSO_4.Be(OH)_2$ and the *p*H for the complete precipitation of the hydroxide. Observations of the cathode potential during the deposition have shown that it is possible to follow the formation of the film of beryllia. Protective films on silver have also been obtained by cathodic treatment in solutions of beryllium nitrate, beryllium chloride, aluminium chloride, and aluminium sulphate. Two explanations of the formation of these films have been suggested.

Dendritic Structures

PART I.—THE INFLUENCE OF CRYSTAL ORIENTATION.

DURING the macroscopic examination of a large number of ingots of the principal copper alloys, a wide difference was observed in the intensity and pattern of the dendritic structure in adjacent crystals, owing to the difference in the rates of cooling of the crystals and in their orientation relative to the surface being examined. This suggested a possible method of determining the orientation of a crystal by reference to its dendritic structure. The usual method of determining orientation by means of X-rays requires the use of expensive apparatus as well as ability to interpret the spectra obtained. It was considered that a simpler method would be useful, even if the accuracy likely to be obtained were less than that offered by the X-ray method.

An examination was therefore made of the dendritic structures in crystals of a number of copper alloys which were then correlated with their lattice orientations. The results of this examination and correlation are given in a paper by Dr. L. Northcott and Mr. D. E. Thomas. Special ingots of alloys of copper containing respectively 0·5% manganese, 1% phosphorus, 2% aluminium, 4% tin, and 15%, 33%, and 47% zinc were examined. The addition of these quantities of alloying elements did not appear to introduce any variation in the manner of crystallization,

* L. E. Price and E. J. Thomas, *J. Inst. Metals*, 1938, **63**, 29.

although there were differences in the ease with which the dendritic structure could be developed by etching.

Columnar crystals were oriented so that a (100) plane—i.e., the cube face of the lattice—was parallel to the direction of growth. Equi-axial crystals in the body of the ingot were of random orientation. The lines composing the dendritic structure were found to be outcrops of {100} planes. These lines became narrower and more sharply defined as the responsible (100) plane approached the normal to the crystal face under examination and, conversely, the lines became broader and more diffuse as the (100) plane approached the plane of the crystal face. A simple method of determining the orientation of a crystal from the dendritic structure is suggested.

A Contribution to the Study of Segregation in Copper-Silver Alloys

THE object of this contribution to the study of segregation by Dr. S. W. Smith and Dr. J. H. Watson is to furnish further evidence of the distribution of the constituents of those binary, ternary, and quaternary alloys of silver exhibiting the behaviour which has been styled "liquation" or "inverse segregation," and to find evidence of the mechanism by which it occurs. It was recognised, therefore, that in choosing suitable alloys for the further investigation of segregation under the conditions of chill-casting, it would be necessary to fulfil at least two conditions in order to accentuate the behaviour and so provide a favourable chance of obtaining micrographic evidence of the mechanism by which it occurs. First, that there should be a widening of the temperature-interval between the initial and final solidification, and second, that the total amount of primary crystallites present in the mass after complete solidification should be relatively small. In view of the known insolubility of nickel in silver and of the limited solubility of nickel-copper alloys in copper-silver alloys generally, it was decided to investigate, more closely than had hitherto been attempted, the effects of the introduction of quite small amounts of nickel into certain of these silver alloys.

The effect on segregation of the substitution of from 1 to 2% of nickel for an equivalent amount of copper in the binary copper-silver alloys near the eutectic composition and near the silver-rich end of the series is that the range of variation in composition is greatly increased; the direction of enrichment of the silver constituent may be completely reversed; the enrichments and impoverishments may no longer occur in a regular gradation from the outside of the casting to the interior, but may give rise to periodic maxima and minima; and the partition of copper (and of zinc) between the silver and nickel constituents of the solidified alloys is such that it tends towards a uniformity in their distribution.

It is suggested that these further observations of liquation or inverse segregation are in accordance with the hypothesis put forward by one of the authors, Dr. Watson, in a previous paper on "Liquation or Inverse Segregation in the Silver-Copper Alloys," and that they afford evidence in support of the explanation which was given of the cause of the segregation observed when the binary alloys of silver and copper solidify in chill moulds.

Alloys of Magnesium

PART VIII.—A FURTHER STUDY OF THE MECHANICAL PROPERTIES OF SOME WROUGHT ALLOYS.

THIS contribution by Dr. J. L. Haughton and Mr. A. E. L. Tate is a report of further work carried out during the past five or six years at the National Physical Laboratory on the constitution and mechanical properties of magnesium alloys. Part VII of the research dealt with the mechanical properties of some magnesium alloys containing aluminium and silver. In addition to a study of the effect of composition, the influence of forging temperature was investigated, and it was shown that markedly improved mechanical properties could be obtained if the breaking down at 380° C. was followed by a further reduction at a temperature in the neighbourhood of 200° C. In the course of the present investigation, which was undertaken to study the effects of additions other than aluminium and silver to magnesium, further information was gained about the effect of work, and this paper is divided into two sections. The first deals with the effect of work on the mechanical properties of magnesium alloys, while the second deals with the effect of additions other than aluminium and silver to wrought aluminium alloys.

As a result of the study of the mechanical properties of magnesium alloys, the authors conclude that before low-temperature (200° C.) working can be carried out with the best results, the deformation given during the breaking-down treatment (330°–380° C.) must be sufficient to penetrate completely through the ingot. A reduction of 50% may not always be sufficient. It was found that 200° C. was about the lowest temperature at which pressing could be safely and practically carried out. A 5½-in. diameter ingot containing about 6% of aluminium and 1·5% of silver was forged so as to give samples with different amounts of reduction, obtained in different ways. The results indicate the improvement obtained by the low-temperature forging.

Annealing between the breaking-down and the low-temperature forging appears to be detrimental to the mechanical properties. It will, however, enable some alloys to be forged at 200° C. which crack under the press if not annealed. A higher breaking-down temperature might obviate this. Fatigue limits determined on four selected alloys show that the fatigue properties are somewhat improved by the low-temperature treatment. It also appears that the ultimate compressive stress is not adversely affected.

No.	Composition, %.					Ultimate Stress, Tons/in.²	Elongation, % on $4\sqrt{A}$.
	Magnesium.	Aluminium.	Silver.	Cadmium.	Zinc.		
1	92	6·5	1·5	—	—	27·3	11·5
2	94·7	3·8	1·5	—	—	24·2	11·7
3	96·9	—	—	—	3·1	19·9	14·2
4	96·0	—	—	—	4·0	24·1	9·4
5	94·7	3·7	—	—	1·6	24·0	11·1
6	94·0	—	—	2·0	4·0	24·0	14·8
7	92·0	6·0	—	2·0	—	25·1	11·6
8	91·6	5·8	1·5	—	1·1	23·2	11·4

In the work on the effect of additions other than aluminium and silver, a number of binary, ternary, quaternary, and quinary magnesium alloys containing aluminium, cadmium, zinc, silver, or manganese were examined after having been submitted to a definite forging treatment No alloy was found which is greatly superior to the silver-aluminium alloys described in Part VII of this series of papers, but some, containing no silver, are comparable with them. The accompanying table gives the best alloys described in this paper, together with results for the silver-aluminium alloys from Part VII. Nos. 1 and 2 are from the previous paper. No. 3 is worthy of special attention, as it contains only 3% of added material and has properties superior to commercially produced material containing 11% of added material. Nos. 4 and 5 are very similar in mechanical properties to No. 2, and they are certainly cheaper to make and probably less corrodible. No. 6 has the highest elongation so far obtained with good ultimate stress. No. 7 is intermediate between Nos. 1 and 2 and is probably cheaper than either, but as it has about the same density as No. 1 it is probably otherwise slightly inferior to either. No. 8 is a very strong alloy with a good elongation, but unless it has some special property other than this, it is probably inferior to No. 1.

Machinability of Some Non-Ferrous Metals and Alloys

Problems associated with the machinability of metals have involved considerable research the results of which are contributing to greater knowledge on this subject. The series of papers prepared for the Glasgow meeting of the Institute of Metals constitute a further important contribution to the subject, the salient features of which are reviewed.

THE machinability of metals involves so many factors, due to the wide variety of types of metals and the treatment to which they are subjected, that data on the subject is complex and frequently difficult to apply, and for this reason the practical and theoretical papers on the machinability of a number of non-ferrous alloys, prepared for the Glasgow meeting of the Institute of Metals, are a useful contribution to a subject about which too little is known. The papers deal with the machining of aluminium and its alloys, copper alloys, and free-turning brass, and a laboratory test for machinability is also included.

Our knowledge of the fundamental principles underlying the many processes used commercially for shaping metals by cutting has increased considerably in recent years, but there is no doubt that machinery, as practised in the machine-shops, is still an art rather than a science. The same material may be machined with distinctly different tools in each shop, or even in the same shop, each particular foreman or operator having his own views on what constitutes the most satisfactory method. Tool angles, speeds, feeds, and the characteristics of the machine tools are all factors that are to some extent interdependent, so that there is likely always to be more than one possible solution for any machining problem.

Aluminium and its Alloys

In recent years the number of components in aluminium and aluminium alloy has grown at a rapid rate, and the machining of these components is of growing importance economically. They may be made as castings, forgings, rolled or drawn products, or extrusions, and may or may not be heat-treated. The motor industry was perhaps one of the earliest to become aware of the advantage of aluminium alloys from a machining point of view, but aircraft manufacturers have since carried the part of machining these materials a considerable way towards perfection. Machined aluminium components, however, are now widely used in many other industries, notably, chemical engineering, shipbuilding and textile machinery.

Methods of testing machinability vary and Messrs. J. H. Dickin and G. A. Anderson endeavoured to assess this property by means of a screw-cutting operation in an automatic screw-cutting machine, but no material difference was obtained between one alloy and another. This was due to the burnishing action of the chasing tools, which masked the true cut surface by superficial flow of the metal. With these difficulties in view, a helical cut test was devised; this consisted of a V groove cut with one traverse at a fairly coarse pitch, and was comparable with the first cut of a lathe screw-cutting operation. After some exploratory work, it was decided to adopt a cut $\frac{1}{16}$ in. deep, 10 cuts to the inch, and it was found advisable to flatten the top of the V to enable the tool to retain its edge under the rather severe conditions of cutting. Alloys with good machining qualities gave smooth, clean grooves with little tearing of the sides, whilst poor machining alloys gave a generally rough and torn surface.

In order to study the general turning properties of cast alloys, a deep cut with an ordinary snub-nosed tool was used. This definitely showed up differences, but the full effect could not be estimated, on account of the fact that any roughness caused in cutting one revolution would be removed during the subsequent revolutions. In order to avoid this, a facing test was devised; this consisted of a $\frac{1}{16}$-in. facing cut using an automatic traverse, the tool being round-nosed with a radius of $\frac{1}{16}$in. The surfaces obtained were sufficiently distinctive to allow assessment of the cutting qualities. This method of carrying out the test readily shows the effect of turning speed. Wrought alloys for general lathe work can be assessed by the same type of test but, in the case of high-speed automatic work, for which free-cutting alloys are generally used, it is necessary to make an additional test for the free-cutting properties. A test devised for this purpose consists of successive cuts of $\frac{1}{8}$ in. at a feed of 0·010 in. per revolution with a straight box-tool. For cutting stock above $\frac{1}{2}$-in. diameter, speeds of 700 r.p.m. are used; for smaller diameters, higher speeds of 1,100 r.p.m. are necessary. The smallness and uniformity of the chips and the condition of the cut surface at each stage are stated to form adequate means for assessment. Tests of this type are performed dry.

The authors discuss machining experiments on pure aluminium and on a range of alloys in both cast and wrought forms, and refer especially to research undertaken recently in several countries with the object of improving the free-cutting qualities of wrought aluminium alloy rod for repetition purposes.

Research has been concentrated on two types of alloys known to have excellent general machining qualities, namely, the magnesium-aluminium series and the copper-magnesium-aluminium series, typified by Duralumin. As a result, there are now available commercially variations of these alloys capable of being machined with much the same tools as free-cutting steel or brass, while giving small broken chips that can readily be removed from the working faces by the stream of lubricant. The problem has been solved on distinctly different lines for each type of alloy. In the case of the magnesium-aluminium alloys, free-cutting qualities have been imparted by the addition of hard, brittle constituents, while for the copper-magnesium-aluminium alloys, additions of elements of low-melting point and of limited solubility in aluminium have generally been preferred. In this country research has been concentrated on the effect of adding tin and antimony to alloys used for the production of extruded machining stock, and after a considerable amount of work in which the main factors of tensile strength and corrosion resistance were considered a final free-cutting alloy has been standardised at 2·7—3·3% copper, 0·45—0·55% magnesium, 0·5—0·7% antimony and up to 0·2% tin.

It is stated that high speeds and light feeds should be aimed at; as a rule it is generally possible to use the highest speed of which the machine is capable, where possible speeds exceeding 400 ft. per min. should be used. The authors recommend precedence in various operations, including turning and boring, planing and shaping, milling, drilling, screw cutting and threading, sawing, filing and grinding; mention is also made of speeds and feeds, and of lubricants.

Machining Properties of Copper Alloys

The range of copper-base materials available to the engineer has become so wide that it is impossible to give consideration to each and every alloy, and in this paper by Mr. W. B. Sallitt, a method of grouping is adopted in

which group A concerns the homogeneous materials such as: copper, alpha brasses, alpha aluminium-bronzes, cupro-nickels, alpha nickel silvers, wrought phosphor- and silicon-bronzes, and beryllium-bronzes in the softened condition. Group B deals with the duplex alloys which includes the alpha-beta brasses, manganese-bronzes or brasses, duplex aluminium-bronzes, nickel-brasses, cast phosphor- and silicon-bronzes and gun-metals. Group C concern the leaded alloys, and consists of copper alloys either of homogeneous or duplex basic structure to which additions of some agent has been made with the specific object of improving machinability.

Mr. Sallitt gives a general review of the machining characteristics of copper and copper alloys represented by the above three groups and deals with present-day machine practice, as applied in each group of materials, and the principles underlying the selection of machine tools, cutting tools, speeds and feeds, and cutting fluids. In discussing the factors influencing the selection of copper alloys for maching purposes the author states that copper alloys selected for products on which a considerable amount of machining has to be performed, should possess optimum machinability consistent with satisfactory mechanical or other essential properties. Where machinability is the most important consideration, one of the free-machining leaded alloys, such as free-cutting brass, is commonly specified. However, lead additions, though always desirable from the point of view of machinability, must be limited or avoided altogether in certain alloys for manufacturing reasons, whilst highly-leaded materials possess certain disabilities which may render them unsuitable for applications in which mechanical or other properties must take precedence over machinability. Nevertheless, the engineer can rarely afford entirely to overlook the question of machinability, even though it may appear to be of secondary importance. The addition of even 0·5% lead may suffice to reduce machining costs considerably, and even where lead additions are prohibited slight improvements in machinability can often be effected by minor modifications in composition, temper, etc.

Free-Turning Brass

Of the large number of copper alloys in commercial use, free-turning brass, as it is commonly termed, is the one that is employed to the greatest extent where ease of machining is the most important requirement, and considerable quantities of this alloy are used in rod form for the production of a great variety of machined components. Because of its wide application a paper by Dr. Maurice Cook and Mr. E. Davis deals with the metallurgical characteristics of free-turning brass and the effect they have on its machining properties. It describes briefly the results of some investigations, which the authors have carried out at different times in connection with this alloy, and the effect on machinability of such factors as variations in the copper and lead contents, addition of other metallic elements, cold working and annealing, and lead particle size and distribution.

Machinability is a quality which it is difficult to define accurately, for machining operations themselves are of very diverse character, and it is well known that the order of machinability for different materials is not the same when judged by different machining operations or machining tests. The machinability of a metal or an alloy is usually related to the speed at which it can be machined, tool wear, power consumption, and the surface finish resulting from the operation. Again, the order of importance of these considerations varies according to circumstances and requirements. Some relative machinability values for a range of commercial alloys are given and these are reproduced in the accompanying table.

Various types of machinability tests have been devised, but it is not possible to base generalisations on the results obtained from any single one of these, and in determining the suitability or otherwise of any material in respect of its machining properties the most satisfactory test is clearly the particular machining operation which is to be used. In the investigation described in this paper the drill penetration test has, for the most part, been used. The authors fully realise the limitations of this test, but, believe that, when carried out with suitable precautions, it does give reasonable reproducible results and provides an indication, in a general way, of the machinability of a material. In addition, however, saw and lathe tests have been employed. The effect of lead particle size and distribution, as well as of cold-work and heat-treatment, on machinability has been investigated, and is discussed.

A Laboratory Test for Machinability

This paper by Mr. A. S. Kenneford, records the results of some experiments carried out on an Oxford-Airey machine. Tests were made on a series of alloys, varying from those said to be easily machinable—*e.g.*, magnesium alloys, "free-cutting" aluminium alloy, and leaded brass, to those machinable only with difficulty, such as Monel metal; the effect of carbon contents ranging from 0·1—1·07% on the machinability of forged steel was also investigated. In essentials, this machine consists of a weighted pendulum, the shaft of which carries, on the one side, a pointer moving over a scale graduated in degrees, on the other a cutting tool, the shape and dimensions of which are given. The pendulum assembly can be moved both vertically and horizontally with respect to the base-plate on which the test specimen is firmly clamped, in order to give varying depths and feeds of cut. Calibration of the machine is carried out in the following manner: The height to which the pendulum rises when allowed to fall freely from the position of maximum potential energy is taken as the zero, and the height to which it rises after cutting the test-piece gives a measure of the energy absorbed during cutting. It can be shown that this energy is pro-

RELATIVE MACHINABILITY VALUES OF A RANGE OF COMMERCIAL ALLOYS.

Alloy.	Copper, %.	Lead, %.	Other Elements.	Tensile Strength, Tons/in.²	Elongation, % on 2 in.	Machinability Figure, Drill Test.
Free-turning brass	57·92	2·95	—	28·0	39·0	100
Tellurium copper	99·21	—	0·75% Te	14·7	36·0	91
Hot-stamping brass	58·9	1·51	—	29·8	29·0	75
Manganese bronze	56·14	1·16	1·0% Sn, 2·0% Mn, 0·77% Fe	41·0	20·0	64
Leaded aluminium bronze	89·12	0·98	9·82% Al	33·3	9·0	52
Naval brass	61·78	—	1·28% Sn	28·1	31·0	44
Muntz metal	59·84	—	—	30·4	34·0	40
Aluminium bronze	89·8	—	10·1% Al	34·7	14·0	38
Nickel aluminium bronze	90·91	—	7·1% Al, 1·97% Ni	29·3	56·0	38
75 : 25 Brass	75·19	—	—	20·0	67·0	36
63 : 37 Brass	62·95	—	—	21·0	65·0	36
High-tensile brass	57·08	—	3·11% Al, 1·92% Mn, 0·88% Fe	48·4	25·0	32
Gun-metal	87·84	—	10·04% Sn, 2·02% Zn	31·7	60·0	32
H.-C. copper	99·94	—	0·04% O_2	14·3	36·5	29

portional to 1—cos a, where a is the angle to which the pendulum swings after making a cut, and, from this angle and the weight of the pendulum, a numerical value of the work done can be calculated.

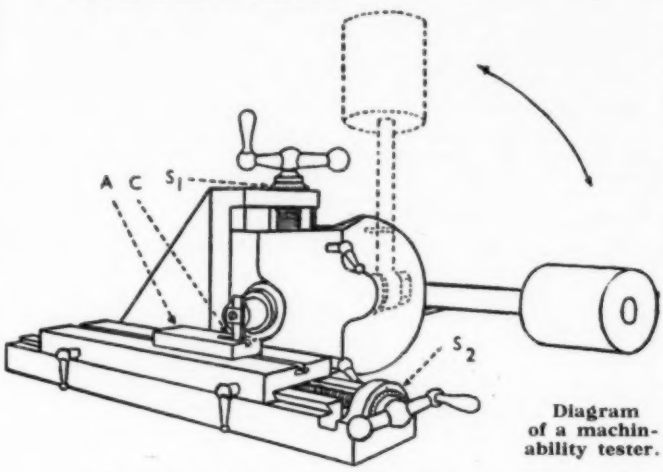


Diagram of a machinability tester.

A diagram of this machinability tester is shown in the accompanying illustration. In the experimental procedure the material A, under test, is firmly bolted down to the base-plate, and the cutting tool C lowered until it first clears the test-piece, when it is clamped, and the scales *S*1 and *S*2 adjusted to zero. The clamps controlling this vertical movement are then released, and a cut taken by lowering the tool slightly and swinging the pendulum. This procedure is repeated until the desired depth of cut is obtained, as measured by the scale *S*1, which is graduated in thousanths of an inch; measurements of the feed—i.e., the horizontal movement, are made from the scale *S*2, graduated similarly. When a cut is being taken, the clamps controlling the various movements are always tightened.

The operation by this apparatus is similar to milling and it is shown that the measure of machinability varies widely over the range of materials tested, and those materials which have a high energy absorption are also those which are most difficult to machine in practice. Bad surface finish and short tool life are also generally associated with high energy absorption, as is the formation of a chip which piles up on the edge of the cutting tool.

An increase in the feed per cut is shown to give greater efficiency in cutting at any given depth for all materials used, and an explanation of this result is offered. The effect of an increase in depth of cut at any given feed appears to be somewhat irregular, however, though, with the heaviest cuts taken, the efficiency of cutting seems to be dependent more on the feed than on the depth of the cut.

Some examples of the use of such a test are given in the experiments on the effect of lead additions to brass, on the effect of increasing carbon contents in a forged steel, in the comparison of some aluminium alloys, and in the study of directional machinability in materials containing inclusions, the results of which are in accordance with what is found in practice. It is, therefore, concluded that this test affords a quick and accurate means of determining the machinability of a series of alloys, or of the effect on the machinability of additions made to a particular alloy.

Standardised Aluminium Alloys in the United States—*continued*

By Robert J. Anderson, D.Sc.

In this, the concluding part of the article dealing with the standardisation of aluminium alloys in the United States, the author gives some typical specifications in common use, and discusses some applications based on the use of recognised standards.

SPECIFICATIONS for various aluminium-alloy products have been issued by the American Society for Testing Materials. The following may be noted:

A.S.T.M. Designation: B 58–37T. Aluminium-base Alloys in Ingot Form for Sand Castings.

This standard covers 12 aluminium alloys to be used in producing sand castings. Limits as to chemical composition are specified.

A.S.T.M. Designation: B 26–37T. Aluminium-base Alloy Sand Castings.

This standard covers aluminium-alloy sand castings having a specific gravity of less than 3. Twelve alloys are specified together with the limits of chemical composition. Minima of tensile strength and elongation are prescribed. Explanatory notes as to applications of the alloys are included.

A.S.T.M. Designation: B 85–37T. Aluminium-base Alloy Die Castings.

This standard covers die castings made by pressure-casting aluminium alloys. Ten compositions are specified, and the limits of chemical composition are set. Typical values for tensile strength, elongation and impact resistance are given.

A.S.T.M. Designation: B 112–37T. Aluminium-base Alloys in Ingot Form for Permanent-mould Castings.

This standard covers 13 aluminium alloys to be used in producing permanent-mould castings. Limits as to chemical composition are specified.

A.S.T.M. Designation: B 108–37T. Aluminium-base Alloy Permanent-mould Castings.

This standard covers permanent-mould castings made by gravity-casting aluminium alloys. Thirteen compositions having specific gravity of less than 3 are specified together with the limits of chemical composition. Minima of tensile strength and elongation are prescribed. Information concerning the corrosion resistance, casting qualities, machinability and principal uses of the various alloys is included.

A.S.T.M. Designation: B 79–36T. Aluminium-manganese Alloy Sheet and Plate.

This standard covers sheet and plate made of an aluminium-manganese alloy. The chemical composition is specified, as well as the tensile strength and elongation for several tempers in various thicknesses. Also tolerances of thickness are prescribed.

A.S.T.M. Designation: B 78–36T. Aluminium-alloy (Duralumin) Sheet and Plate (Aluminium-Copper-Magnesium-Manganese).

This standard covers ordinary duralumin sheet and plate. The limits of chemical composition are given. Tensile

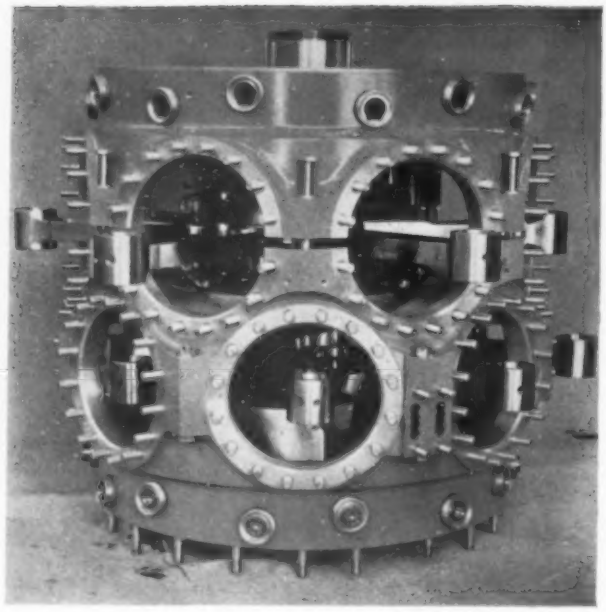


Fig. 1.—Forged and heat-treated crankcase for a radial aircraft engine (Aluminium Company of America.)

properties are specified for material as annealed, heat-treated, and rolled after heat-treatment. In addition, thickness tolerances are set.

A.S.T.M. Designation: B 89–36T. Aluminium-alloy (Duralumin) Bars, Rods and Shapes (Aluminium-Copper-Magnesium-Manganese).

This standard covers bars, rods and shapes made of ordinary duralumin. It applies to a great variety of sections in rolled or extruded bars and rods, and also rolled or extruded shapes. The chemical composition and tensile properties are specified. Besides, dimensional tolerances are prescribed.

A.S.T.M. Designation: B 109–36T. Aluminium-Magnesium-Chromium Sheet and Plate.

This standard covers sheet and plate made of an aluminium-magnesium-chromium alloy. The chemical composition is specified as well as the tensile strength and elongation for various tempers in a range of thicknesses. Also permissible variations in thickness are given.

A number of standards for aluminium-alloy products have been prepared by the Federal Specifications Executive Committee to cover such supplies used by departments of the United States Government. The specifications so far approved are listed in the latest issue of the Federal Stock Catalogue. Other standards for manufactures in aluminium alloys have been drawn by divisions of the United States Army and the Navy. Sources of still other specifications applied in American practice have been previously mentioned.

Table VII lists a number of standards for aluminium-alloy manufactures produced by the Aluminium Company of America and the conforming specifications of the American Society for Testing Materials and the Federal Procurement Division (United States Treasury Department).

TABLE VII.

AMERICAN STANDARDS FOR ALUMINIUM ALLOY PRODUCTS.

Kind of Product.	Alcoa Symbol.	A.S.T.M. Designation.	Federal Designation.
Sand castings	43	B 26–37T	QQ–A–371(*a*)
Sand castings	112	B 26–37T	—
Sand castings	195	B 26–37T	QQ–A–371(*a*)
Sand castings	214	B 26–37T	—
Sand castings	355	B 26–37T	—
Permanent-mould castings	A108	B108–37T	—
Permanent-mould castings	122	B108–37T	QQ–A–371(*a*)
Permanent-mould castings	A132	B108–37T	—
Permanent-mould castings	138	B108–37T	—
Permanent-mould castings	142	B108–37T	QQ–A–371(*a*)
Die castings	85	B 85–37T	—
Die castings	93	B 85–37T	—
Sheet and plate	3S	B 79–36T	QQ–A–359
Bars, rods, shapes and wire	3S	—	QQ–A–356(*a*)
Tubing	3S	—	WW–T–788
Forgings	14S	—	QQ–A–367
Sheet and plate	17S	B 78–36T	QQ–A–353
Bars, rods and shapes	17S	B 89–36T	QQ–A–351(*a*)
Bolts, nuts and studs	17S	—	FF–B–571(*a*)
Tubing	17S	—	WW–T–786
Forgings	17S	—	QQ–A–367
Sheet and plate	52S	B109–36T	—
Sheet and plate	53S	—	QQ–A–334
Bars, rods, shapes and wire	53S	—	QQ–A–331

(*a*) Ingots for casting.

Typical Applications

The development and standardisation of improved aluminium alloys and manufactures thereof have made possible many new applications. Taken altogether, these account in large measure for the rapid increase in consumption of aluminium during late years. Progress in the utilisation of various wrought products for structural purposes has been outstanding. Recent applications of strong aluminium alloys in the broad field of transportation and for heavy-duty structures have been particularly impressive. Some others are quite as important, if less spectacular.

In the United States standardised products made of aluminium alloys are used commonly as parts, or in structures, by numerous industries. The following are large consumers: aircraft, automobile, building, household appliance and railway equipment. Moreover, a wide and growing field of application is for general structural work, including many kinds of equipment and machinery.

Aluminium alloys are employed as materials in aircraft construction primarily because of their high strength-weight ratio or low specific gravity. Here also, their resistance to corrosion is important. Special treatments are, however, often required to improve it. Structural parts for aircraft are made of wrought high-strength aluminium alloys, and include beams, struts, wing coverings, fittings, wheel rims, bolts, nuts, rivets and screw-machine products. They are manufactured from shapes produced by rolling, forging, drawing, or extrusion. Non-heat-treated alloys are employed for fabricated parts subjected to low stresses—for example, cowling, fuel tanks, and streamline coverings. Aluminium-alloy castings are also applied in aircraft construction. Typical parts are engine castings, fittings, wheel hubs and brackets. Heat-treated forgings are used for certain highly stressed parts of aircraft, including propellers, pistons, crankcases, bearings supports and fittings. Fig. 1 shows a forged crankcase for a radial aircraft engine (Pratt and Whitney). The alloy is A51S, and the forging is heat-treated.

Aluminium-alloy parts, both cast and wrought, are used generally in the manufacture of American motor-vehicles. Rapid progress has been made during late years in the application of aluminium-alloy products for the construction of buses and trucks especially. The substantial saving in weight resulting from the use of light materials effects considerable economy in the operation of such vehicles. As in other fields, standardised alloys are normally specified for automobile work. With regard to truck bodies: roof sheets, panels, floor sheets, tail-gate sheets, dump-body sheets, gusset plates, side posts, slats, rub rails, door frames, bolsters, longitudinals, corner posts, etc., are made of suitable wrought alloys. Those most commonly employed are 3S, 4S, 17S and 27S, the composition and properties depending upon the requirements of service. Aluminium-alloy pistons, cast in permanent moulds, are standard equipment in automotive engines. A few other parts include crankcases, oil pans, bearing caps and cylinder heads.

Aluminium alloys are being employed more and more extensively in American architectural work for both inside and outside purposes. The following applications may be noted: spandrels, grilles, marquees, ornaments, windows, sills, copings, flashings, cornices, doors, hardware, screens, ventilators, store fronts and miscellaneous trim. Alcoa 43 alloy has been used generally for cast products in building construction, and 53S is employed for extruded sections utilised for a variety of purposes, including the assembly of windows.

Large quantities of aluminium alloys are consumed yearly in the United States for manufacturing household equipment and appliances. Both cast and wrought cooking utensils are made of aluminium alloys, and the simple corrosion-resisting compositions are favoured. An important use of aluminium alloys is in small washing machines for the home. The well-known Maytag washer, for instance, is constructed mostly of aluminium-base products. Another important application is for household vacuum cleaners. Castings are employed in the assembly of these machines. Household furniture is made of extruded aluminium-alloy sections, the articles being formed bywelding.

Aluminium-base products are finding extensive use in the railroad-equipment industry of the United States. The applications are very numerous, and include not only fittings and small parts but also complete trains. Owing to many investigations and service tests, the alloys employed for constructing railroad rolling stock have become fairly well standardised. In modern passenger cars the alloy 17S-T has been used considerably for underframe sections and other structural members which are highly stressed. The alloy A 17S-T is also specified for such construction. Typical framing applications of structural shapes or section made in these alloys are purlines, carlines and posts. Extruded sections of the alloy 53S, heat-treated, are used generally for interior trim. Also the composition 3S is employed where stresses are low. The "City of Denver," an articulated train of the Union Pacific Railroad Co., shown in the July issue, is built mainly of aluminium-alloy products. In addition, various parts of Diesel power units for light-weight trains are made of aluminium alloys.

Another application of aluminium alloys in railroad equipment is for tank cars. Fig. 2 shows a tank car for transporting ethyl acetate. It is built of Alclad 17S-T plate, the Alclad coating being on the inside only. The total weight is 42,000 lb., and the capacity is 8,000 gals.

Aluminium alloys are employed in general structural work for a great diversity of purposes. The range of application is very wide both for small machinery and in heavy engineering. In the case of the former, some uses are for high-speed reciprocating parts, rotors of air-motors, envelope-folding machines and portable tools of various kinds. In the case of the latter, some remarkable applications are for bridge construction, dragline booms, excavator buckets, and bulkheads of dams. Lightness of structure is generally the major consideration in utilising aluminium alloys, rather than other materials, for such purposes. Alcoa 27S-T alloy is specified for the floor systems of bridges and 53S-T for railings.

Fig. 2.—Tank-car of aluminium-alloy construction. (Aluminium Company of America.)

Fig. 3.—Beer barrel in an aluminium alloy. (Aluminium Company of America.)

Another important field of use for aluminium alloys is in the construction of chemical, food and related equipment. On account of their resistance to corrosion, the Alcoa alloys 3S, 52S, 53S and 214 are employed for such apparatus in addition to substantially pure aluminium. A recent development in the United States is the aluminium-alloy beer barrel. This item is now being produced in large quantities by the Aluminium Company of America. The alloy specified is 53S-T. Fig. 3 illustrates an Alcoa beer barrel.

As already pointed out, the manufacture of aluminium-base commodities in the United States is mostly in accordance with specifications drawn by engineering organisations, producers and consumers. Specifications or standards are essential not only to assure control in processing operations, but also quality and adequate performance in service. The general application of standards in this country has been an important factor in furthering the use of aluminium-alloy products throughout industry.

Mechanical Tests on Aluminium Alloys

Mechanical tests were carried out by Mechling & Jack* on the aluminium alloys 14ST and 24ST. The former was in the form of a large hand-forged billet and the latter in the form of a $\frac{3}{4}'' \times 6''$ rectangular bar. In addition to the determination of the usual mechanical properties, tension impact values were also obtained for both materials. Care was taken to obtain all specimens from the same stock and to define the condition of the material by photo micrographs and grain direction. The results obtained compare favourably with the generally accepted mechanical properties of these alloys. Considerable variation of the mechanical properties with grain direction was found, the magnitude of which are shown in tabular form and by graphs. Although the results obtained compare favourably with those generally accepted for these alloys, the tests have shown quantitatively the variation of the properties with grain direction.

*Amer. Soc. Test. Mat. Preprint No. 48A, 1939, 8pp.

Business Notes and News

Wild-Barfield's New Premises

The continued expansion of the business of Messrs. Wild-Barfield Electric Furnaces, Ltd., made it necessary for them to purchase land for the erection of a modern factory with facilities that would enable them to handle the increased output concomitant with improving deliveries.

The Company have acquired land at Watford, and the entire organisation (comprising offices, works, research and demonstration heat-treatment shop) will be transferred as soon as the new works are ready. The present situation, however, has made it impossible to give an exact date when the new works will be ready for occupation, and manufacture will continue for the present at the present works in North Road, Holloway, London, N. 7. Temporary offices have been taken at Bushey, near the site of the new works, and to which the design and drawing offices, accounts, sales and executive departments have now been transferred. Readers are requested to address all correspondence to the temporary offices at 2-6, Highwood Avenue, Bushey, Herts.

The associated company of Messrs. G. W. B. Electric Furnaces, Ltd., have also moved their registered offices, Accounts, Eternite and Quenching Oil sales departments to the same address, but please note that all correspondence and inquiries relating to Gibbons-Wild-Barfield furnace designs, contracts, etc., should be addressed to Dibdale Works, Dudley, Worcestershire.

Steps already taken will increase present manufacturing facilities to some extent. Both companies are certainly making every endeavour to maintain deliveries of new and existing orders, and to reduce any delays to the minimum.

Industrialisation of the Soviet East

The steps being taken by the Soviet government to develop the industrial wealth of Central Asia are exemplified by the plans to construct a large hydro-electric power station at Ust-Kamenogorsk, on the upper reaches of the River Irtysh. Of 250,000 k.w. capacity, it will be the first large hydro-electric station to be erected in the Eastern territory of the U.S.S.R. The plans involve the buiding of a dam, with a three-chamber navigable sluice and a weir, at Ust-Kamenogorsk, through which fish from the Arctic Ocean can enter the upper reaches of the Irtysh. To regulate the flow of the Irtysh waters an earthen dam with a navigable sluice will be built at Lake Zaisan, 265 miles beyond the hydro-power station. While the construction work is proceeding the river waters will be diverted into a canal running parallel with the main channel. The station should be in full operation by 1943, and supplying power to the new polymetallic industry now being developed n the Altai region.

Trolley Buses for Durban

Durban Corporation (Passenger Transport Department) have placed an order with the General Electric Co., Ltd., London, for electrical equipment for thirteen 70–72 seater trolley buses. This is the second repeat order from Durban Corporation for such equipment to be placed with the G.E.C. The chassis and mechanical details are by Leyland Motors Ltd.

Scottish Steel Works Busy

The Scottish steel works are exceptionally busy, the current output on the West Coast exceeding all previous production records; Government orders accounting for the major portion of the working. There are, however, strong demands for steel for general commercial and industrial usage, as well, this including boiler makers, shipbuilders and constructional engineering. There is a consistent demand for basic pig iron, and a reasonable call for hematite.

METALLURGIST wanted. Fully qualified in the analysis, preparation and metallographic examination of high-speed steel specimens. Latest instruments available. State experience, age and salary required. Apply Box No. 103, "Metallurgia," 21, Albion Street, Gaythorn, Manchester.

Deposits of Coal, Lead and Tin found in North Kazakhstan

A prospecting party recently discovered a new coal deposit, provisionally estimated to contain 78 million tons of coal, on which a mine has been sunk capable of producing 100,000 tons of coal a year for the needs of the local population. The new coalfield is some 69 miles from Ak-Kul Station. Substantial deposits of coal have also been found in the village of Yablonovka of the Enbekshilder district. These are estimated to contain 180 million tons. A coal mine with an annual output capacity of 15,000 tons is already in operation, and a second mine of an annual capacity of 50,000 tons is being sunk. The southern part of North Nazakhstan is altogether rich in useful minerals. Deposits of lead, molybdenum and tin, the extent of which is now being determined, have been found there.

The Institution of Mechanical Engineers

The Institution of Mechanical Engineers is carrying on the bulk of its work at a temporary address in the country, "The Meadows," Betchworth, Surrey (Telephone:, Betchworth 63), but the Institution building, in Storey's Gate, will remain open, possibly during restricted hours, for dealing with personal inquiries and for members or others wishing to make use of the Library. The majority of the members of the Institution are engaged upon work of national importance or are serving in technical branches of H.M. Forces, and some 6,000 have offered their services through the Central Register of the Ministry of Labour.

Mining Iron Ore in Lincolnshire

An important project for the mining of iron-ore in North Lincolnshire to meet the greatly growing needs of the iron and steel industry there, is taking shape at Santon. where a shaft 200 feet deep is being sunk so that iron-ore may be more expeditiously and economically worked than by the present system of open-quarrying, which is largely employed in the Lincolnshire ironstone field. The new system is on similar lines to that employed in the Cleveland district and in Northamptonshire and Cumberland.

The ironstone stratum which it is proposed to work is nearly 30 ft. thick and about 120 ft. below the surface. The shaft is being sunk below the stratum to provide room for a loading station for the ironstone, which will be conveyed to the surface up the shaft and carried by overhead transport system to the works of Frodingham Ironstone Mines, Ltd., for the Appleby-Frodingham Steelworks of the United Steel Companies.

Richard Thomas & Co., Ltd.

The directors' report on the years' results of Richard Thomas & Co. comments neither on the year's trading nor on the changes in the constitution of the board. In August, it will be remembered, important changes in the board were announced. Col. Sir W. Charles Wright, chairman of Baldwins, and Mr. S. R. Beale, chairman of Guest Keen and Nettlefolds, resigned and three new directors unassociated with the sheet trade took their place. The new directors are the Earl of Dudley, Sir James Lithgow and Mr. A. C. Macdiarmid. Sir William Firth became chairman and Mr. John E. James, chairman of the Lancashire Steel Corporation, was appointed managing director.

The results for the year to April 1, 1939, show a heavy fall in profits, though these will not be regarded with surprise since the tinplate recovery is of comparatively recent date. The group profits total £1,118,100, against £2,139,517. Losses and running in expenses of the Ebbw Vale Works cost £270,855, after crediting £66,357 from contingencies; interest payable is £237,626, after the transference of £200,000 from general reserve, being the proportion of Debenture interest for the year estimated as attributable to the cost of reconstruction at Ebbw Vale and Redbourne, depreciation takes £440,000 and tax £77,076. These are the largest debits to the group profit and loss account, and with other charges they have a net profit figure for the year of £42,061.

The South Wales tinplate industry is now working much nearer to capacity and the revenue position has greatly improved since the Company has substantial orders in hand. It is likely, therefore, that this year will enable the Company to commence payment of dividends on the £3,120,346 of 6½ per cent. Preference share capital, which is non-cumulative until March 31, 1943. But for some years the complexion of the Company's financial policy will be of a conservative nature.

Reviews of Current Literature

Transactions of the American Institute of Mining and Metallurgical Engineers

This volume published by the Institute of Metals division, contains in its 355 pages the papers and discussions presented before the division at meetings held at Detroit, October 17 to 19, 1938, and at New York, February 13 to 16, 1939. They cover a wide field, and the annual lecture, given by Professor Daniel Hanson, of the University of Birmingham, on "Creep of Metals," adds new light to one of the problems of this age. He discusses the correct evaluation of this physical property in a manner that is both interesting and instructive. The lecture is printed in this book.

Mr. Morris Cohen's paper on the "Age Hardening of Duralumin," and a paper on the "Effect of Plastic Deformation on the Age Hardening of Duralumin" (R. W. Lindsay and J. T. Norton) are not only of decided value in themselves, but are made still more useful by the discussions which accompany them. The light alloys, however, do not receive preponderating attention, although two other papers deserve mention—"The Solubility of Lead and Bismuth in Liquid Aluminium and Aluminium-Copper Alloys" (L. W. Kempf and K. R. Van Horn), and "Equilibrium Relations in Aluminium-zirconium Alloys of High Purity" (W. L. Fink and L. A. Willey).

"The Supposed High-Temperature Polymorphism of Tin," by C. W. Mason and G. E. Pellissier, junior; "Preparation of Pure Zinc," by E. C. Truesdale and G. Edmunds; and the "Microhardness of Bearing Alloys" (L. L. Swift), all deserve mention. Perhaps it is invidious to select any particular papers from this volume of Transactions, for all add to current information and give much food for thought and further development—as is clearly evident from the discussions.

Recrystallization of cold worked aluminium and aluminium alloys; development of abnormally-large grain sizes in rolled and annealed copper sheet; tarnish films on copper; X-ray study of the iron-palladium and nickel-palladium systems; and electron diffraction effects from polished zinc surfaces, are included in this collection of papers.

Published by the American Institute of Mining and Metallurgical Engineers, 29, West 39th Street, New York, U.S.A. $5.00 net.

Aluminium Engineering Sections

THE marketing of aluminium has been marked by the production of really good sales data books that give the user all possible information. This new publication issued by Aluminium Union Ltd., (The Adelphi, Strand, London, W.C.2), is yet another book that makes every attempt to give users that information they need in choosing and ordering extruded aluminium sections.

A short but concise introduction points out that the many ways in which extruded aluminium sections can be used by the engineer are becoming self evident with the growing use of the metal, mentions its low cost and its specific advantages such as lightness, corrosion resistance, workability and mechanical properties, together with a note on anodic and dyed anodic finishes.

The notes on the applications of various alloys are most useful, particularly to any engineer who may be considering any particular application of aluminium for the first time. Four non-heat-treated (or work hardened), alloys are detailed, and six heat-treated alloys discussed. This is followed by a very practical note on the limits of manufacture. The sheet on the mechanical property specifications for extruded sections gives proof stress, ultimate tensile stress, elongation, Brinell hardness and density; and the engineer will certainly find the tables of standard tolerances very useful.

The contents give dimensions, with weights, and diagrams, of aircraft sections, angles, channels, corner and cover moulds, door plates, drip moulds, fillets, flat bars, fluted strip, beads, gutterings, half-round mouldings, handrail sections, hexagons, I-beams, quarter rounds, railroad and road vehicle sections, rounds, squares, edgings, Tees and Zeda. Six pages of sectional drawings illustrating some uses of aluminium extruded sections as applied to commercial bodywork, buses and coaches are commendable in their clarity.

This excellent data book is completed by a numerical index of all the sections contained in it; this including an index of redrawn sections with equivalent extrusion die numbers.

What is Steel?

ALL those concerned in the many phases of the steel industry are not specialists, and do not possess the knowledge of the specialist. For these people, and they are many, there has long been a need for a book which explains the nature of iron and steel. Such a book has been published, under the above title. The author says, very pertinently, that the specialist is too used to dealing with equals in his field; very often he is so prejudiced by his technical way of thinking that he is no longer aware which of these technical matters still belong to general learning, and what must be considered specialised knowledge.

The short introduction starts the book on the right note by differentiating between carbon and special steels; carbon is then dealt with, and this is followed by a brief survey of the physics of atoms and the space lattice of iron. Logically enough, this is followed up by an illustrated chapter on the distribution of carbon in steel, then by a longer section on the iron-carbon diagram. This section is one of the clearest in a book that is commendable for its concise style throughout.

Heat-treatment is given the proportionate space it deserves. The various alloys are considered separately, with their applications and effects—all the time with reference to the basic equilibrium diagram—there are sections on stainless and heat-resisting steels; high-speed tool steels, and the testing of steels. A brief but very clear outline of production of iron and steel makes a useful completion to an interesting and informative book.

Extracts show the clear style adopted by the author, and retained by the translator: introducing the subject of alloys in steel, he says: "The most important alloy, carbon, has already been discussed in detail in the previous sections. At this point one may, however, repeat that at the transition from the alpha- to the gamma-lattice, and particularly with the reversed process, the relatively slow carbon atom needs a certain minimum time in order to keep up during the change of position that then takes place: it is further hampered by the iron atoms, travelling in the opposite direction. We make use of this phenomenon in hardening, by quenching the steel abruptly from the range of the solid solution, so that the carbon atom cannot get out of the gamma-lattice in time, but remains enclosed in the alpha-cube after the break-up of the lattice, and that thereby a state of compulsion results—*i.e.*, the hardness. The speed necessary for this process has been called the "critical cooling speed." If the steel is alloyed with other suitable alloys, it is still more difficult for the carbon atom to pass by all these new hindrances—*i.e.*, the alloy atoms, which are likewise dispersed throughout the whole space-lattice—it now requires still more time for the change of position implied in the break up of the lattice. It is therefore no longer necessary to quench so very quickly in water in order to retain the carbon atom enclosed in the lattice; a milder quenching in oil is sufficient—the critical cooling speed has become reduced . . . we can now also see why the water-hardening steels—*i.e.*, the pure carbon steels—as well as the low-alloy steels, can be hardened to only a limited depth, while the medium- and high-alloy steels can be hardened throughout." A clear description that the layman should understand without difficulty.

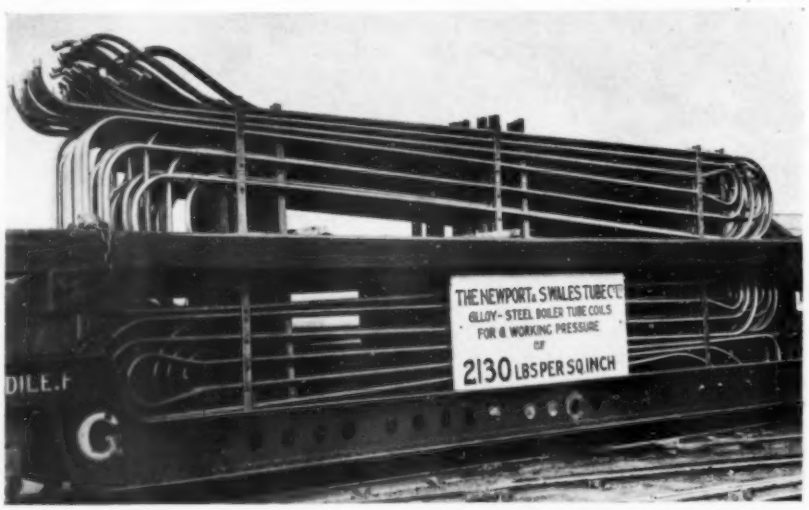
He also gives a timely word concerning the fundamental differences between high-carbon steels and high-speed tool steels: "A well-hardened carbon steel of high carbon content is, as regards hardness, at room temperature, not in any way inferior to a hardened high-speed steel. A great difference arises in that the hardened carbon steel becomes soft on heating (tempering) already at about 250° C., and therewith loses its cutting capacity, while the high-speed tool steel after correct heat-treatment retains its full hardness and cutting capacity up to about 700°. These properties are even further increased by tempering. The most outstanding characteristic of high-speed tool steel is consequently its extremely high tempering stability."

This book gives the commercial man whose work lies in the steel trade, a valuable foundation upon which he can appreciate more technical works with a greater degree of facility—if he so wishes. And there is the valuable factor, as mentioned by the author that the mentally-active man will, in our technical age, occupy himself with technical matters, even with no definite ulterior objects in view, just as he may perhaps inform himself about historial questions or the fundamentals of astronomy, in order to do justice to his age. In the same way he is also anxious to gain a technically-correct conception of steel.

By Leopold Scheer, Macdonald and Evans, London, 6/- net, Ably translated from the German by F. L. Meyenberg.

Molybdenum Steel for Loeffler Boilers

THE Loeffler boilers installed at the Brimsdown Power Station, which are the first of their type to be used in the British Empire, consist of two units, each of 210,000 lb. per hour, working at a pressure of 2,000 lb. per sq. in., and a temperature of 940° F. at the boiler outlet. The saturated steam generated at 2,000 lb. per sq. in. in the evaporator drums is forced by means of a turbine-driven pump through the tubes of the radiant superheater surrounding the combustion chamber of the boiler. It then passes through a convection superheater, at the outlet of which it divides—about one-third going to the turbine plant and two-thirds returning to the evaporator drums. It is there discharged below water-level through special nozzles to evaporate further feed-water.



Superheater tubes in molybdenum steel for working pressure of 2,000 lb. per sq. in. and a temperature of 940° F.

As the superheater tubes must withstand this high steam pressure at a temperature approaching 1,000° F., the use of a creep-resistant molybdenum-bearing steel was essential. The steel chosen was Colville's Special Creep Resistant Steel, a chromium-molybdenum steel of the following analysis:

Carbon	0·10—0·15%
Silicon	0·15—0·25%
Sulphur	0·04% max.
Phosphorus	0·04% max.
Manganese	0·4—0·6%
Molybdenum	0·5—0·65%
Chromium	0·7—0·9%

The selection of this steel was due to its superior mechanical properties and resistance to sealing and corrosion at these high temperatures, together with its weldability, as oxy-acetylene welding was employed extensively for pipe joints throughout the installation.

Every precaution was taken to ensure the reliability of of the steel. A small cast was first made, and experimental tubes fabricated from this were subjected to tests of every description, some of which are given below:

MECHANICAL PROPERTIES AT ROOM TEMPERATURE.

Maximum stress	32·8 tons per sq. in.
Yield point	19·6 " "
Extension on 2 in.	33·0%
Reduction of area	59·0%
Izod impact value	99, 94, 91 ft.-lbs.

MECHANICAL PROPERTIES AT HIGH TEMPERATURES.

Tensile Tests—Rate of Strain 0·06 in. Min.

Testing Temperature.	Maximum Stress, Tons/sq. in.	0·05% Proof Stress, Tons/sq. in.	Extension on 2 in.	Reduction of Area.
950° F.	31·3	11·0	30%	74%
1,000° F.	29·4	10·3	32%	72%

IMPACT TESTS AT HIGH TEMPERATURES.

Testing Temperature.	Impact Ft-lbs.	
20° C. = 68° F. ..	95	104
100° C. = 212° F. ..	121	123
200° C. = 392° F. ..	121	104
300° C. = 572° F. ..	111	113
400° C. = 752° F. ..	85	89
500° C. = 932° F. ..	63	64
600° C. = 1,112° F. ..	56	52

IMPACT TESTS AFTER PROLONGED HEATING (TESTED COLD).

	Impact Ft.-lbs.
Initial test	94, 94, 99
After 2,000 hours at 450° C. (842° F.)	106, 108, 103
" " 500° C. (932° F.)	99, 94, 100
" " 550° C. (1,022° F.)	97, 98, 95

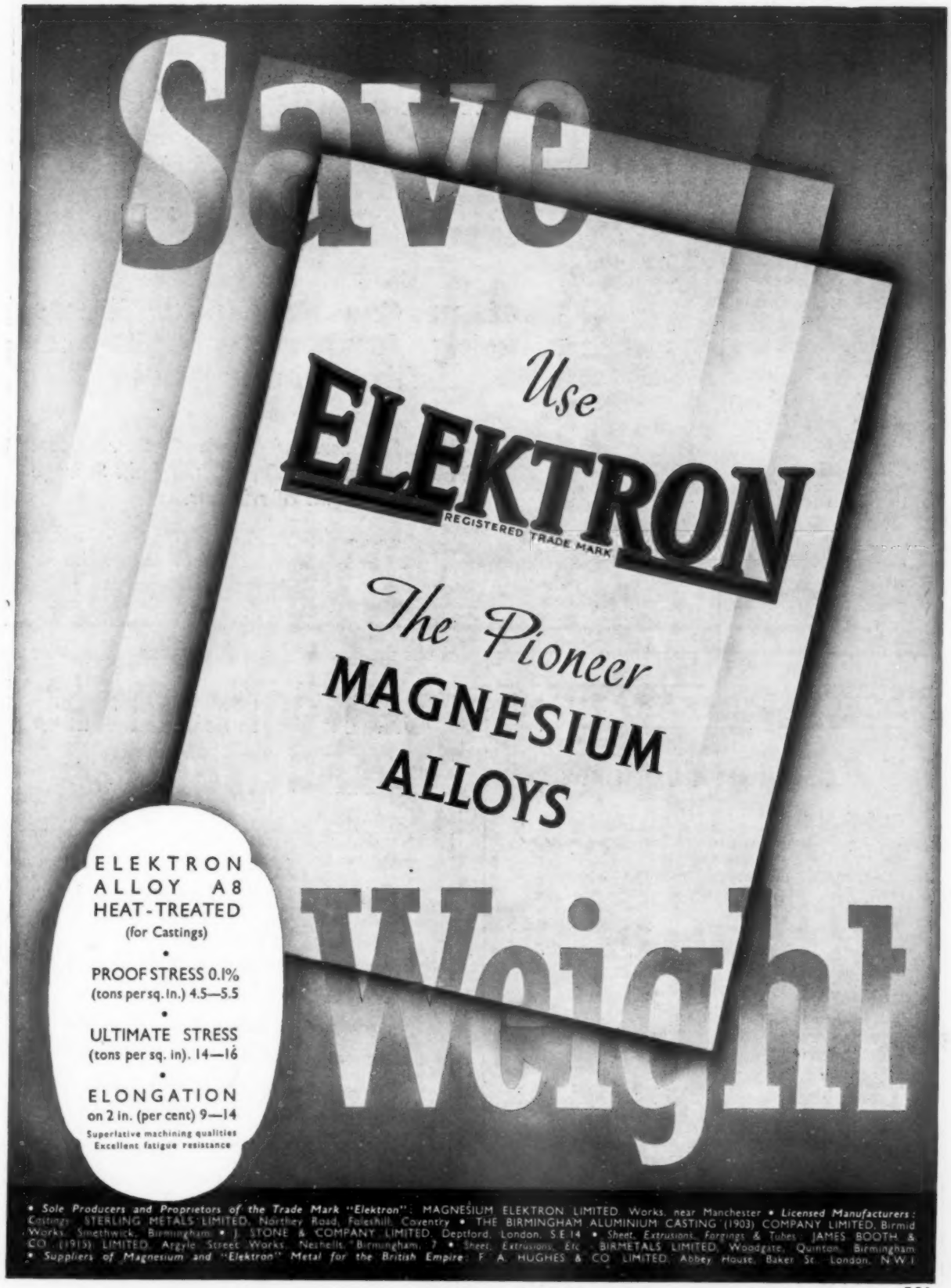
These tests show no sign of embrittlement after a long time at high temperature.

Numerous mechanical tests of welds were made, and welds were also sectioned and examined microscopically. The superheater joints were normalised by a special sectional gas burner after welding, and the soundness of the welds was confirmed by means of X-ray tests.

A series of creep tests carried out on this steel at the National Physical Laboratory, at temperatures of 950° F. and 1,000° F., gave results in complete agreement with those obtained in Messrs. Colvilles' extensive laboratories.

During the manufacture of the steel, tests were continued to ensure that there was no abnormality in any cast, and that the high temperature properties were fully up to the standard of the experimental steel. The uniformity obtained in the creep-test results from each cast indicated good control over the manufacturing conditions of these special molybdenum creep-resisting steels.

* *Alloy Metals Review*, September 1939.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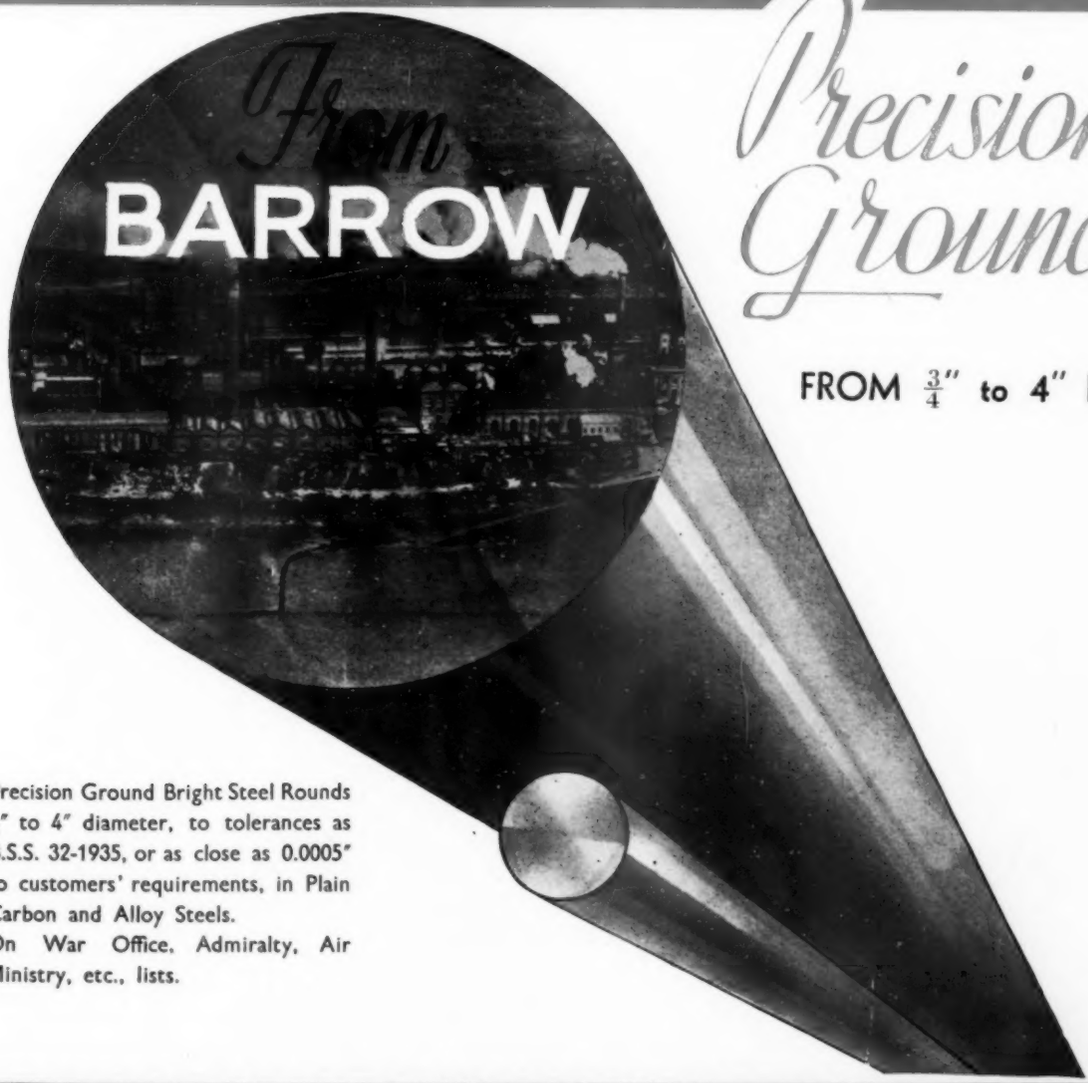

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